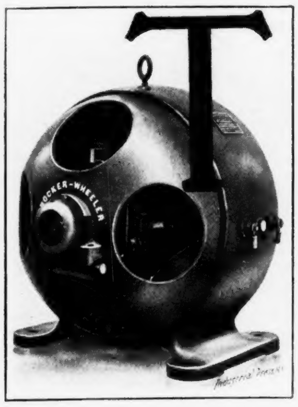
MACHINERY.

September, 1902.

ELECTRICITY AS A MOTIVE POWER FOR MACHINE SHOPS.

WITH SPECIAL REFERENCE TO THE ELECTRICAL EQUIPMENT OF THE WILLIAM R. TRIGG CO., RICHMOND, VA.

William Burlingham.



THE arguments against the installation of electric motors for machine shops are constantly decreasing with the increase of the motor systems. For new shops the argument against the use of electricity is nil. For rehabilitating old shops, there are naturally many points to be considered, the principal of which are: Dismantling the driving mechanism of old machines and installing new motors; loss of shafting and appurtenances, boilers, engines, etc. The boiler power necessary would then be, only that used for heating the plant. To reimburse a firm for so doing, necessitates that the economy and improved feed adjustment due to the electric motor driven machines must earn a good interest on money lost on old installation plus that invested in the new driving machinery. The convenience of being able to work one tool only, on a hurry job, without being compelled to run the entire line of shafting, is one factor of economy. The mobility of the tools is another especially on light machinery.

The general impression is that in an electrical installation, the only saving factor is that due to the economy caused by lack of countershaft and main line shaft friction; by the smaller number of men necessary to manage the power plant; by getting rid of the condensation of steam in the pipes of a large plant supplied from a central boiler installation, and by the smaller amount of money invested in power conductors. The fact is that *the greatest* economy is often lost sight of, and that is the power of an electrically-driven machine of the modern type, if really driven, to save time and therefore money by its power of varying the cut to suit the work. The latest installations have twelve speeds under control of the operator and so it is comparatively easy for him to run his cut to the full capacity of the cutting tool. With the ordinary cone pulley and countershaft drive the best cutting speed is as liable to come between the cone speeds as it is to come exactly on the cone speed. This is the item in which experience in the use of motor-driven tools, has shown in a high degree the economical range of the electric motor. Another great advantage of the system is its adaptability to overtime work.

Fig. 1. Interior of Engine Room of the Virginia Electrical Railway & Development Co., which supplies the Current for the Shops of the Wm. R. Trigg Co.

How many of us have seen an entire plant of 200 horse power in operation, merely to face off a flange or to turn a pulley. It can be easily seen that a few such jobs would pay for placing motors on all the shop machinery that is liable to be used for such purposes.

The improvement in the daylight illumination of such

shops must be seen to be appreciated to its full value, and the extra space secured for the use of the cranes in the rapid handling of material is another argument in favor of its adoption.

This is also one of the factors by which the output is increased unconsciously.

For the old shops with low ceilings, of which there are many in this country, the low countershaft and short belts do not allow the machines to be used to their full capacity, because of the belt slipping. This may be a small item, it is true, but at the present time when competition is so keen, all these items count in the cost of the product. It has been found from experience that the personnel of the men is improved and that they are more apt to drive the machines to their full capacity.

The shop is neater and cleaner, there are fewer corners for the reception of dirty waste, and tools are not so easily mislaid. Another point seldom brought up is the increased floor capacity of a shop, due to the use of these tools. No room need be allowed for belt drives, and tools as a result can be brought closer together; and because there is no line shafting running in a fixed direction, the tools need not be located for favoring belt drives, but can be placed fore and aft the shops, or crossways, in fact in the direction best suited for their intended work, or in the space most convenient.

In a machine shop or manufacturing establishment of ordinary size the power is usually transmitted from one or more engines by means of belting, long lengths of line shafting and countershafts. The amount of power necessary to keep this mass of shafting and belting in motion is a very large percentage of the maximum output of the engine, as high as 70 per cent at times and an average of 40 per cent at least of this total power developed. It is evident that this same loss will take place whether the shop is running at its maximum or at one-quarter of its rated capacity.

The electric drive has, of necessity, a loss between the engine and the point of application of the power; but as electric systems are designed to-day this loss is comparatively small with everything under way—much less than with the belt system. It has the added advantage of being lessened proportionally as the various machines are cut off, and they do not remain a drag upon the generating plant. Such a system, therefore, permits of the use of one or more machines independently of the others, with a percentage loss referred to the machine in use, and not to the maximum output of the plant. It is also evident that with this great frictional loss in the belt drive, the power plant must be, on an average, twice as large as its more economical competitor, the motor drive. Now considering the comparative cost of all the elements of each system, we find that the first cost of the electric system is not at all expensive compared with its opponent, for the following reasons: First, the size of the power plant is cut down; secondly, the belts, line and countershafts are taken out, and thirdly, the steam pipe system is greatly decreased. Against this we have the addition of the generators, motors and wiring. It has been demonstrated in several factories that this favorable cost of installation of electricity as compared with steam is a fact. When we consider this cost, the economy of operation and increase in efficiency of cutting tools, the advantages of this system become self-evident.

It is not necessary that there be a large central station in the neighborhood as a source for the power, because one can generate one's own electricity cheaper than one can buy it in the majority of cases. We are not all located near Niagara Falls or the James River. I give a few figures from the plant of the Curtis Publishing Company, Philadelphia, Pa., from the "Electrical Review."

"This plant consists of three Babcock & Wilcox, 250 horse power, boilers at 160 pounds steam pressure, with a Green economizer of 600 horse power and induced draft. For regular work there are three large units of 200 kilowatts, 250 volts continuous current Westinghouse generators, each driven by engines 14½ and 28 inches by 18 inches stroke, tandem compound, at a speed of 200 revolutions equal 325 indicated horse power.

"For night and Sunday work, watchman's lights, etc., there is one small unit 50 kilowatts 250 volts driven by an engine 11 by 12 inches, 275 revolutions per minute, developing 80 horse power. The exhaust steam is used for heating purposes, and to keep the back pressure down in the low-pressure cylinder, the Webster system is used. The exhaust steam passes through a Cropson heater 600 horse power, returning to the feed water heater at a temperature of about 170 degrees F. The cost of running this plant for a month was $1,455.53, 41.3 per cent of this being for fixed charges (taxes, insurance, interest, depreciation, repairs, etc.). The heating cost averaged throughout the year, per month $211.83, leaving net cost of $1,244.50. During the month there was delivered to the switchboard 83,400 kilowatt hours or 111,510 horse power hours. The net cost therefore per kilowatt hour was 1.49 cent and per horse power hour 1.11 cent.

"The average price from a central station would be from 2 to 3 cents per horse power hour. The comparative economy of the isolated and central station plant can be easily seen."

The Power Plant of the Virginia Electrical Railway and Development Co.

The reasons for the higher prices of the central station are due to the fact that it costs them nearly as much to deliver the goods as it does to generate it, while the isolated plant has the added advantage of using the exhaust steam for heating the buildings. It must be understood that these figures refer to complete, up-to-date plants, and not to a motor stuck up in solitary grandeur in one corner of a machine shop. The machine, boiler, ship fitting shop, in fact the entire plant of the shipbuilding firm of the William R. Trigg Company, Richmond, Va., is fitted with the latest modern types of electric motors. This company do not generate their own electricity as they are exceptionally fortunate in their situation, their current being supplied to them by the Virginia Electrical Railway & Development Company. The power house of the Virginia Development Company is 250 feet long by 112 feet wide. The total available fall of water at the power house is 25 feet. The turbines are situated in submerged chambers beneath the boiler rooms.

There is also a complete steam auxiliary for use during one month in the year when the river is in flood from the spring freshets. The plans provide for 11,000 horse power in 11 units. The turbines were made by the Stillwell-Bierce & Smith-Vaile Co. They are the regular type of submerged horizontal turbines 2-51-inch working together making one unit. A Lombard water wheel governor is used for controlling them. The generators are from the General Electric Co., of the heavy railway type, rated at 750 kilowatts each; direct current 500 volts multipolars at 110 revolutions per minute. The armature shaft carries an 87,000-pound flywheel, which runs with the turbine as well as with the engine. When the engines are used, the coupling bolts are withdrawn between the turbines and generator and the engine coupled, the operation requiring about fifteen minutes. The engines are vertical steeple compound, made by Allis-Chalmers, and are 20 and 40 inches by 42 inches stroke, fitted with Reynolds-Corliss valve gear, operated by two eccentrics, the steam and exhaust valve being operated by different eccentrics. Their best economy is obtained when working at 800 horse power, with a maximum capacity of 1,500.

The main steam line is 14 inches diameter and the exhaust line or header is 36 inches, exhausting into a Worthington siphon condenser. There are six batteries of Babcock & Wilcox boilers of two boilers each, a total of 12 boilers; steam pressure 150 pounds, 500 horse power each, with a guarantee for 50 per cent. overloading. The Holly system of draining is used for the steam pipes, the water being returned to the boilers. The switchboard is built on a gallery about 26 feet above the engine room floor. An underground conduit system of Edison tubes is used. Those at present laid down in the city have a length of about 70,000 feet.

The capacity of the plant has been extended by the addition of a storage battery for use in the lighting system. During the morning hours when the demand for current is comparatively light, these batteries are charged and drawn on later for the evening supply. It was furnished by the

Electric Storage Battery Company of Philadelphia. There are 280 elements of their latest improved type, installed with 140 cells in series on each side of the three-wire system. The capacity of the battery at about 70 degrees F., is 180 amperes for 8 hours, on each side of the system, with a maximum pressure at end of discharge of 238 volts. This ceeding and is very well worth the consideration of other cities that are similarly situated.

The Equipment at the William R. Trigg Co.'s Works.

The plant installed in the machine shop at the works of the William R. Trigg Company is the "four-wire multiple

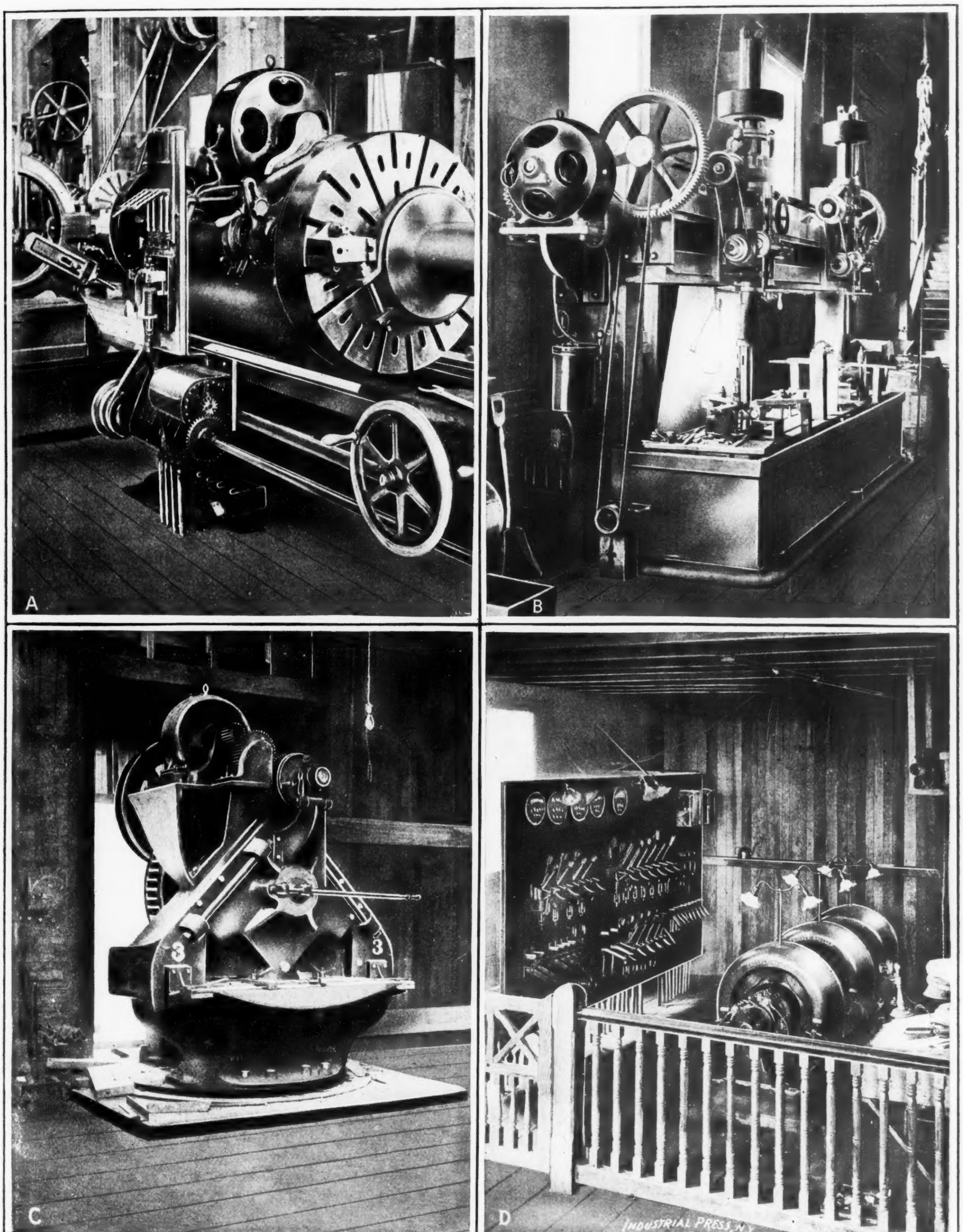


Fig. 2. A.—36 inch x 25 foot Putnam Lathe, 7.5 H. P. Motor. B.—Newton Duplex Rod Boring Mill, 7.5 H. P. motor. C.—Double Angle Shear, 10 H. P. motor. D.—Rotary Transformers and Switchboard.

company are also part owners in the Richmond Industrial & Development Company, who have constructed a modern factory building of brick, in which tenants may rent any space they desire, with any amount of power, very suitable for small industries or experimental work. This venture is suc-

voltage system," as developed by the Crocker-Wheeler Company, Ampere, N. J. The ship fitters' tools, etc., are run by constant speed motors, all, with one or two exceptions, of the Crocker-Wheeler manufacture. The multiple voltage system works excellently in practice. One man looks after 96

motors in addition to his other work. The men easily become accustomed to the methods of operating the machines and express themselves as well pleased with the system, claiming that they would never go back to the old belt system if they could help it. Their work is under perfect control, as they are able to instantly stop the tool at any part of the work. The work is turned out quicker, it may be unconsciously, but the fact remains that less time is taken to do a certain job than with the old methods, even with the few months' practice they have had. The method of the electrical operation is shown in Fig. 3.

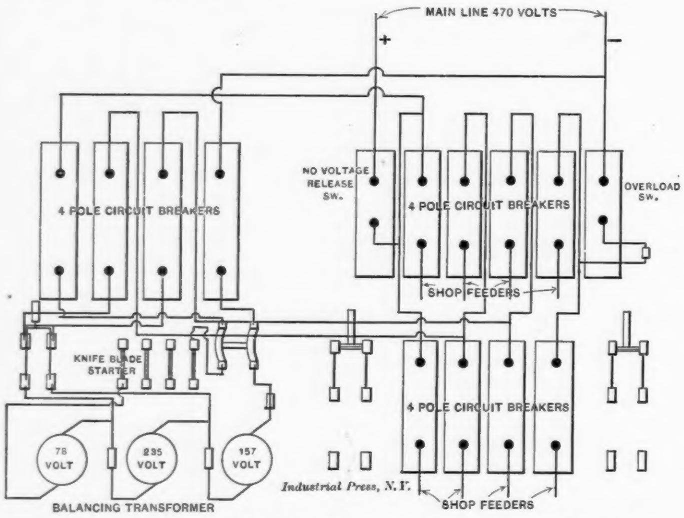


Fig. 3. Plan of Wiring of Four-wire System used at the Wm. R. Trigg Works.

In one corner of the machine shop is the electrical department, which contains the balancing transformer, with polished slate switchboards, shown in Fig. 2, D. To this switchboard the current is delivered at a difference of potential of 470 volts. The positive wire leads to an I. T. E. 500 ampere, no voltage release breaker, or in other words, a breaker that automatically cuts or breaks the circuit whenever the voltage of the main supply ceases. There is also an ordinary breaker of the same capacity for the negative wire. The current is then conducted to 200-ampere breakers and from them to a Crocker-Wheeler cut-off blade starter, the latest type of which is shown in Fig. 4. A closing cut-off switch of iron and

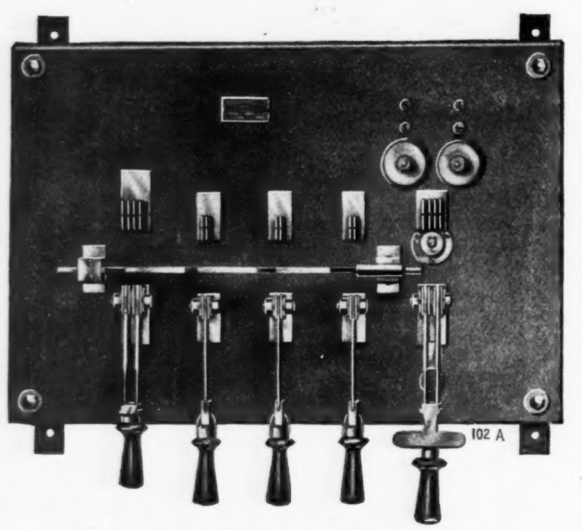


Fig. 4. Crocker-Wheeler Cut-off Blade Starter.

mica sections completes the circuit through the motor and starting resistance. The resistance is then cut out step by step by closing the knife blade resistance switches. An interlocking device prevents the switches from being closed in any but the proper order. If the line voltage fails, the cut-off switch opens, thus disconnecting the motor from the line, which cannot be replaced without opening all the resistance switches. From this the current is conducted to each end of the set of balancing transformers, one to the 78-volt and the other to the 157-volt machine. There are three rotary transformers on a common shaft, and they transform to a voltage of 78, 235 and 157 respectively. They run at a common speed of 1,100 revolutions per minute.

From a conductor connecting the 157 and 235-volt and the 78 and 235-volt transformers, wires are led to a double-pole switch. From this switch they are connected to two 150-ampere I. T. E. breakers; and from thence each line leads to a pair of 150-ampere breakers. It will be seen from the accompanying plan of wiring, Fig. 3, that there are two sets of four breakers on the panel board, one above the other, one for each side of the machine shop. The combination of voltage possible is as follows:

$$78 = 78$$
$$157 = 157$$
$$235 = 235$$
$$78 + 235 = 313$$
$$157 + 235 = 392$$
$$78 + 157 + 235 = 470$$

This four-wire system extends to each motor in the shop through a switch and circuit breaker, the object of the breaker being that if the tool should bite or gouge into the work and throw a heavy load on the motor, it will immediately break connections, saving burning out the armature, etc. From this controller, of which Fig. 5 shows a method of connections, the current enters the motor on the machine. The principle of operation is as follows: On the first notch of the controller the motor is thrown into circuit with the

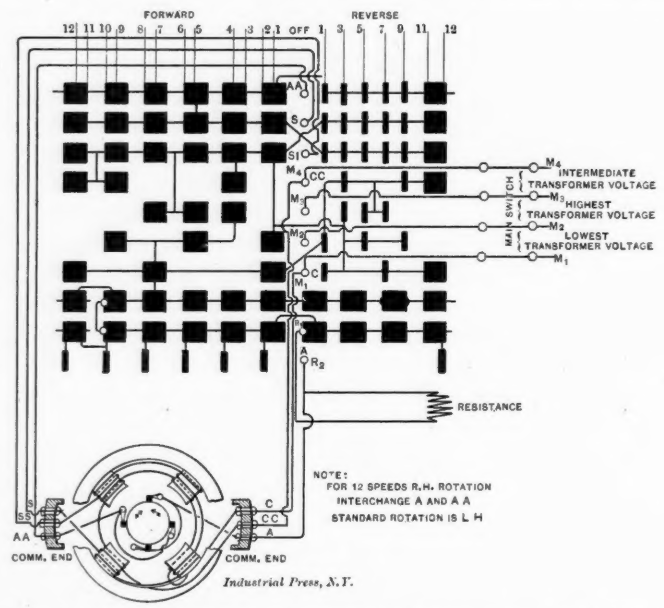


Fig. 5. Connection Diagram of Controller for Reversing Compound Motor.

78-volt current, and certain constant resistance in the armature circuit. The second notch throws out this extra armature resistance; the third notch, the 157-volt current with the same resistance as at first; at the fourth notch this resistance is thrown out and so on for twelve notches, giving the machinist twelve motor speeds, and on a lathe that is back-geared, this may give him forty or fifty speeds to work with, enabling him to find that requisite for any class of work. It is not until one has had this variation of speed at his command that the economy of it can be appreciated. Suitable fuses are, of course, distributed throughout the line, but the location of these is more for the electrical than for the mechanical end, as our province is to understand the general working of the system only.

The circuit breakers used, I T E, have an adjustment from 25 per cent. below to 50 per cent above the actual rating, and at this actual rating they do not exceed 20 degrees above the temperature of the surrounding atmosphere.

The type of motor used by the William R. Trigg Company is that manufactured by the Crocker-Wheeler Co. With these machines the full load may be thrown on or off instantly without causing any sparking or necessitating any readjustment of the brushes. They behave similarly when the load is raised from one-fourth normal load to 25 per cent overload and they withstand loads 50 per cent greater than rated capacity without appreciable sparking. The rise in

temperature is not greater than 40 degrees above surrounding air after a five-hour full load run. An overload of 25 per cent can be carried for an hour without increasing this rise over 5 degrees and a 50 per cent. overload can be carried momentarily. The armature is well ventilated, the commutator surface large, the field coils well protected and mechanical parts are amply strong. The field coils are wound upon cylindrical heavy insulated bobbins, which are removable from the poles by taking off the pole shoes. The armatures are wound with round wire triple cotton covered and the coils are continuous from commutation bar to commutation bar. Provision is made for circulation of air in the interior of the armature and out through the commutation connections. The current density of the brushes range from 20 to 40 amperes per square inch for ordinary carbon and for carbon interleaved with gauze as high as 70 or 80 amperes per inch.

The standard belt speed ranges from 2,000 to 4,500 feet per minute, depending upon the size of the machine. The number of square feet of belt surface per horse power averages from 70 to 90 per minute for single belts and 45 to 55 per minute for double belts.

The speeds of the standard load do not vary more than 5 per cent. when the load raises from 0 to full load. The moderate speed machines give increased output over the same size low speed and run nearer the sparking and heating limits, but are claimed to run in every way satisfactorily.

STANDARD SPEEDS FOR MOTORS.

Standard Low.		Weights.	Standard Moderate.	
Horse Power.	Revs. per min. at 500 Volts.		Horse Power.	Revs. per min. at 500 Volts
225	425	23210	170	530
150	480	12800	125	675
100	530	6825	90	690
75	570	6850	60	870
50	660	4315	45	1000
35	730	3215	32	1050
25	780	2325	26	1100
20	820	1790	20	1250
15	840	1465	13	1175
10	880	965		

Weight does not include pulley, base, frame or rails, or blade starter.

The present installation of motors at the Trigg Company's works is equivalent to 1,152.75 horse power and the present mean load with all air compressors running is 331 horse power, or 28.8 per cent of the sum total of motor horse power.

It is proposed to install a new air compressor, 200 horse power; 3 Gantry cranes, 75 horse power; a shaving exhaust system, 32 horse power, and 2 caisson pumps (25 horse power each), 50 horse power.

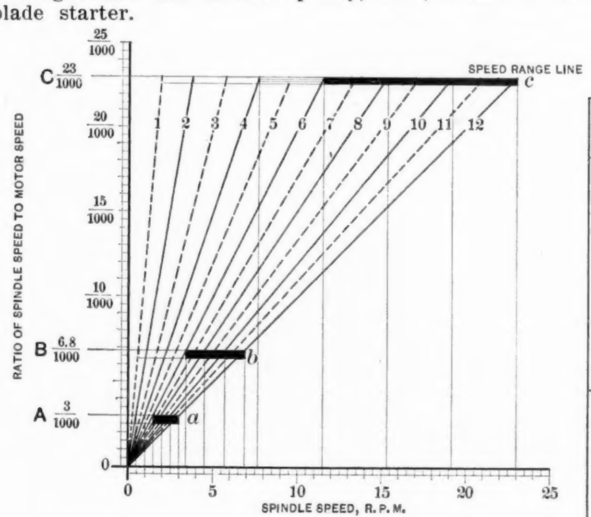
From the present figures we can see that only about 30 per cent. of the available horse power is in average use. With the engine and belt system we could easily use up this amount in friction on a 1,500 horse power plant and we would have this same amount of friction if we were running a 5 horse power machine or the entire system, whereas with the motor system the friction is practically proportional to the power used. With an isolated plant under ordinary conditions, we can probably figure about 1½ cent per kilowatt hour, or 1.11 cent per horse power hour.

The efficiencies of these motors are as follows:

H. P.	Full Load.	¾ Load.	½ Load.	¼ Load
225	93.5	92.5	80.4	84.7
150	92.1	89.8	86.3	76.5
100	93.0	92.0	89.6	83.1
75	90.7	89.5	86.5	77.2
50	90.1	88.5	84.8	74.4
35	89.5	87.5	83.5	73.3
25	89.4	87.0	82.5	70.5
20	88.5	86.7	82.7	71.5
15	86.5	85.3	80.3	68.3
10	85.5	85.4	83.0	74.5

This shows the high efficiency of these machines and the small loss due to their employment as an intermediary, compared with the usual belt pulley and shafting.

The motors in this shop are either compound series or shunt-wound. The diagrams of the windings are given in Fig. 8.



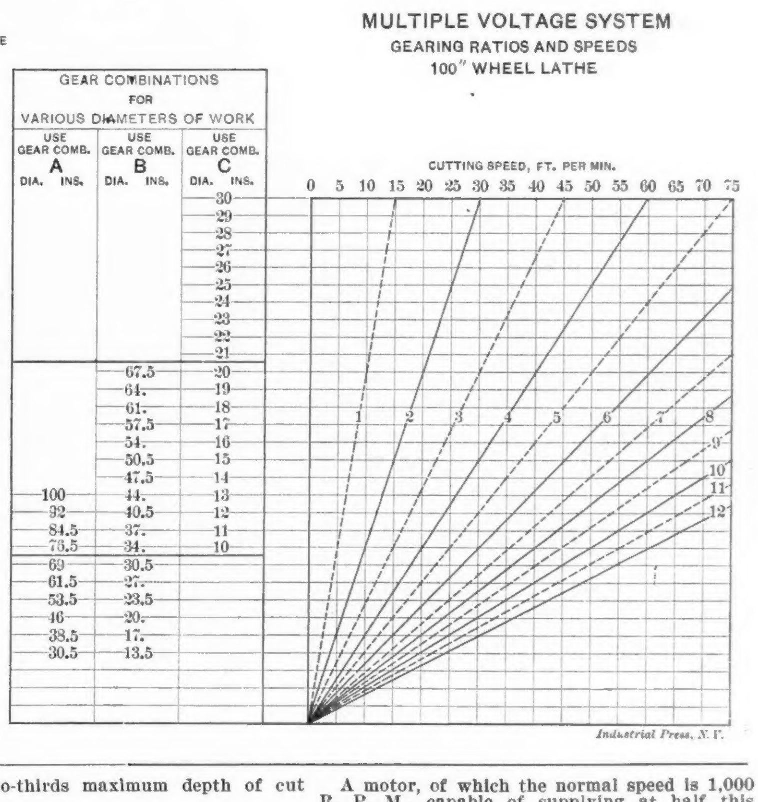


Chart I. shows the determination of the gearing ratios of a 100-inch wheel lathe operated by an electric motor on a multiple voltage system; also the spindle speed of the lathe for each gearing ratio and voltage.

Chart II. shows the proper gearing ratio and voltage to obtain a given cutting speed with work of a given diameter. Plotted for a range of diameters of from 10 inches to 100 inches on diameters over 30 inches, maximum depth of cut and feed. On diameters under 30 inches, two-thirds maximum depth of cut or feed.

Cutting speeds from 15 to 60 feet per minute.

A system of six voltages of relative values, 2, 4, 6, 8, 10, 12.

Controller positions 2, 4, 6, 8, 10, 12, corresponding to these voltages and controller positions 1, 3, 5, 7, 9, 11, intermediate between them.

A motor, of which the normal speed is 1,000 R. P. M., capable of supplying at half this normal speed the maximum horse power demanded, which is 20 horse power; and capable of supplying at one-third this normal speed the lesser horse power demanded by lighter cuts on diameters under 30 inches, which is 13.3 horse power.

Three combinations of gearing.

Fig. 6. Gearing Ratios and Speeds, 100-inch Wheel Lathe.

The charts, Fig. 6, page 5, of the gearing ratios and cutting speeds of a 100-inch wheel lathe show the method that is used for determining the correct speed ratios and the combinations of gears necessary for a certain cutting speed. This principle is applicable to all classes of machine tools and explains itself.

Electrical Equipment in Ship Fitters' Shed.

The ship fitters' shed of the Trigg Company is fitted up entirely with constant speed motors, equipped with double pole switch and Cutler-Hammer starters. The operation of the tools is very satisfactory. There is a line of shafting at each side of the shed; the west side driven by a Crocker-Wheeler, type D, 15 horse power motor, shunt-wound, 800 revolutions per minute, 470 volts and 27.5 amperes. This motor, as well as that in the east side, is attached to the lower chords of the roof trusses, which also hold the hangers.

This 15 horse power motor drives a grindstone and seven tools, viz.: One Bethlehem rotary shear, No. 4; two Hilles & Jones punches, No. 1; one Hilles & Jones punch, No. 0; one Hilles & Jones shear, No. 1; one set of straightening rolls, 8 rolls 6½ inches diameter 4 feet long, and one Hilles & Jones angle shear, No. 3.

On the east side there is a Milwaukee motor, shunt-wound, type 30 B, 30 horse power, 625 revolutions per minute, 500 volts (run at 470), 50 amperes. This motor drives a grindstone and six tools, as follows: One 5-foot radial drill; one small vertical drill; one rivet making machine, Acme; one counterboring machine, Fitchburg Machine Works; one plate planer, side, Hilles & Jones, No. 0, and one set of light bending rolls, 18 feet long, Hilles & Jones.

The other tools are separately driven, each by its own motor, viz.: Large bending rolls, Hilles & Jones, 22 feet 2 inches between heads, diameter of top roll 27 inches and diameter of bottom rolls 23 inches; three-roll machine. The roll-driving motor is of the C. & W. type, 35 D, compound-wound, 35 horse power at 470 volts, 58.5 amperes and 700

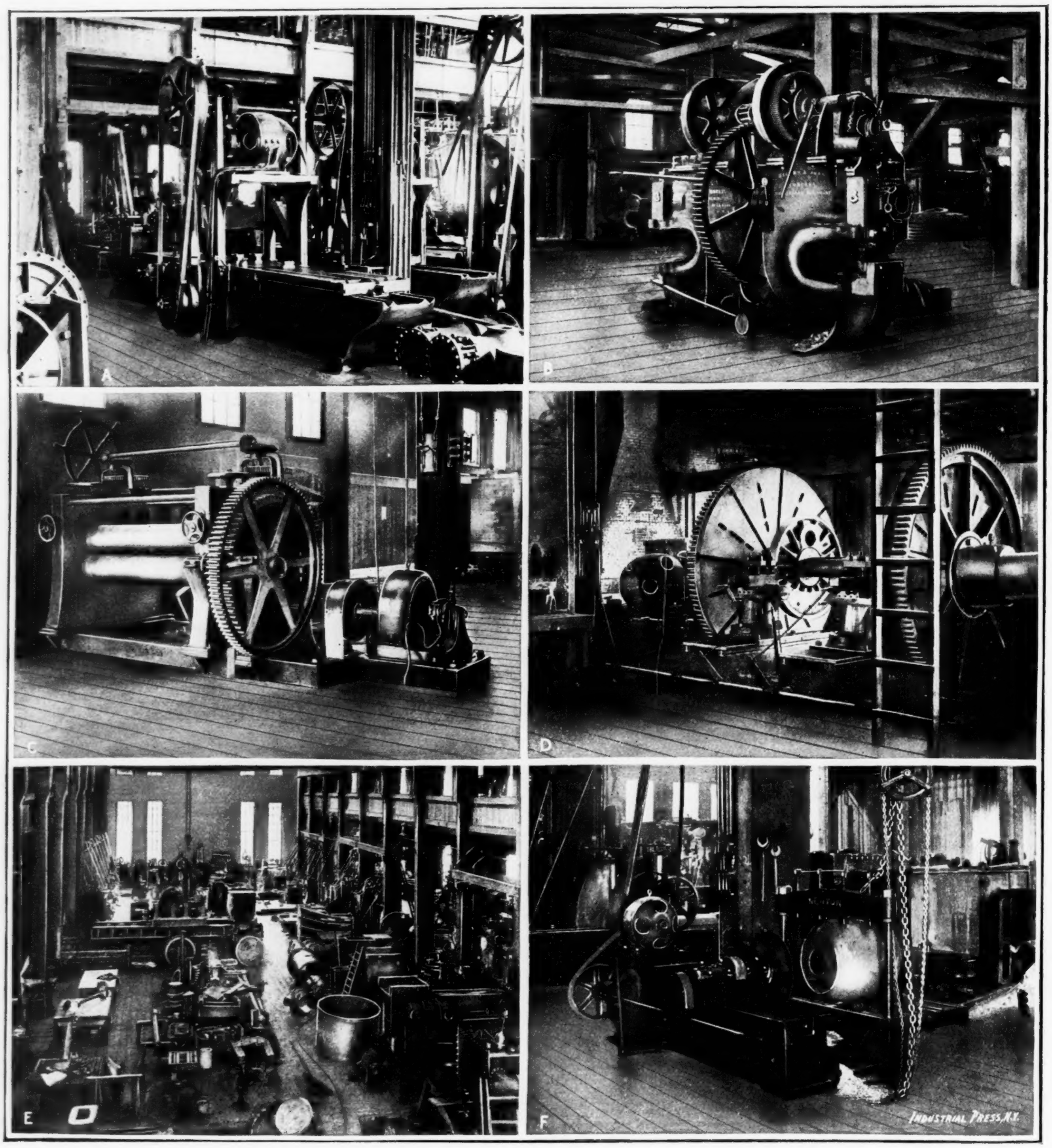


Fig. 7.

A.—36-inch Planer, 15 H. P. Motor.
B.—No. 3 Double Punch, 10 H. P. Motor.
C.—12-foot Straightening Rolls, 15 H. P. Motor.
D.—100-inch Wheel Lathe.
E.—View of the Machine Shop.
F.—Newton Cold Saw, 5 H. P. Motor.

revolutions. The top roll is lifted by a C. & W. 10 D compound-wound motor, 10 horse power, 470 volts, 17 amperes and 800 revolutions. These motors start very gradually, as the resistance of the controller is thrown out and are fully up to their work. It would be preferable, however, to have the lifting motor series wound.

The straightening rolls, Hilles & Jones, are 12 inches diameter, 6 rolls each, 6 feet long, with a C. & W. compound-wound motor, 15 D, and 15 horse power at 470 volts, 27 amperes, 825 revolutions. The Hilles & Jones double punch, No. 3, has a capacity of punching 1¼ holes or using 14-inch shears, C. & W. motor, compound-wound, 10 D, 10 horse power, 470 volts, 17 amperes and 875 revolutions. The Hilles & Jones duplex, or side and butt planer, is 25 feet side and 8 feet butt, 2-inch plate, two 15 horse power, C. & W. type, 15 D, compound-wound motors, one for side and one for butt planing, each 470 volts, 17 amperes and 875 revolutions. The Hilles & Jones double angle shear is 8 x 8 inches, 1 inch angle thickness, 10 D, motor 470 volts, 17 amperes, 875 revolutions. The two Hilles & Jones punches, No. 4, have a 1½-inch punch or 16-inch shears, each of the C. & W. motor type, 10-I, compound-wound, 470 volts, 18.3 amperes, 850 revolutions, 10 horse power.

MOTOR SPECIFICATIONS FOR MACHINES IN SHIP FITTER'S SHED.

Tools.	Type Motor.	Maker.	Winding.	Horse Power.	Volts.	Amperes.	Revolutions per min.
22′ Bending Rolls.							
Driving	35D	Crocker-Wheeler	Compound	35	470	58.5	700
Lifting	10D	"	"	10	470	17	880
12″ Straightening Rolls	15D	"	"	15	470	27	825
No. 3 Double Punch	10D	"	"	10	470	17	875
Duplex Planer	(2) 15D	"	"	15	470	27	825
Double Angle Shear	10D	"	"	10	470	17	875
No. 4 Punch	10–I	"	"	10	470	18.3	850
No. 4 Punch	10–I	"	"	10	470	18.3	850
No. 2 Punch	5F	"	"	5	470	8.7	1000
No. 3 Hor. Punch	7.5F	"	"	7.5	470	13	900
N. Y. Compressor		Gen. Electric	"	100	470	175	600 to 690
Rand Compressor	12–0	Milwaukee	"	120	500	195	580
No. 6 Sturtevant Blower		Sturtevant	"	12	470	14	1600
No. 6 Sturtevant Blower		"	"	12	470	14	1600
West-side Shafting	15D	C. & W.	Shunt	15	470	27.5	800
East-side Shafting	B .30	Milwaukee	"	30	470	50	625

A total horse power, exclusive of the Sturtevant Blowers, which are in the Smith Shop, of 416½. With the compressors omitted, there is 196½ for the ship shed tools alone.

The Hilles & Jones punch, No. 2, has a ¾-inch punch, 12-inch shears, a C. & W. motor, type 5-F, compound-wound, 470 volts, 8.7 amperes, 1,000 revolutions, 5 horse power. The Hilles & Jones horizontal punch, No. 3, has 12-inch gap, 1 x 1-inch punch, a C. & W. motor, compound-wound, type 7.5-F, 470 volts, 13 amperes, 900 revolutions, 7½ horse power. The New York air compressor is a General Electric, 100 horse power, 470 volts, 175 amperes, 600 to 690 revolutions. Air is delivered at 100 pounds pressure; capacity, 500 cubic feet. The Milwaukee motor has a voltage of 470 volts, 195 amperes, 120 horse power, 580 revolutions. In the smith shop are two No. 6 Sturtevant blowers, with 12 horse power Sturtevant motors, 470 volts, 14 amperes and 1,600 revolutions. Exclusive of the Sturtevant blowers, which are in the smith shop, a total H. P. of 416½. With the compressors omitted, there is 196½ for the ship shed tools alone.

Shunt and Compound Motors.

Whereas the ship shed motors are nearly all compound-wound, the motors in the machine shop are both shunt and compound-wound. Those for the ship shed have a variable load with high starting torque and for this it is necessary to have the motor compound-wound. When the load is practically constant, the shunt-wound motor is the best. In a shunt motor system the current is divided, a small portion of the total being used only for exciting the magnets, the main current being led off direct to the external circuit. In a compound motor system, the shunt and series windings are combined. There are two sets of coils on the magnets. The series coils, consisting of comparatively few turns of wire of large section and low resistance, through which all the current of the external circuit passes; and the shunt coils, of many turns of wire of small section and high resistance, through which a small portion of the total current passes. With the shunt winding the motors are practically self-regulating, that is, they maintain a constant counter-electro motive force under varying conditions of load. I give the working principles of these two types of motors for the reason that, although familiar enough to the electrical engineer, they are not at all so to the mechanical designer or machinist, for whom this article is written.

Experiments to Determine Power Required to Drive Machine Tools.

On page 8 are data derived from experiments on three of the machine shop tools, especially prepared for this article. The machines were working under ordinary shop conditions and the data were gathered during the regular work. A 62-inch x 30-foot Putnam lathe, turning a cast-iron cylinder head 36½ inches in diameter, of hard cast iron; the tool of Sanderson self-hardening steel. A motor, Crocker-Wheeler, type 10-I, shunt-wound, 10 horse power, 850 revolutions, 470 volts, 18.5 amperes.

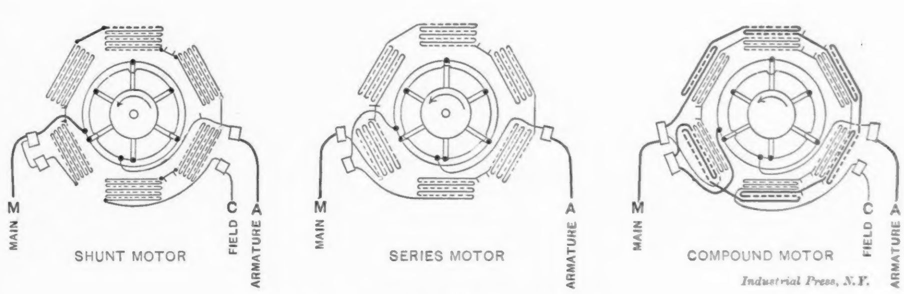


Fig. 8. Shunt, Series and Compound Motors.

The second experiment was with a Woodward & Powell planer, 36 inches by 12 feet, of the Crocker-Wheeler motor, type 15-I, compound, 15 horse power, 840 revolutions, 470 volts, 28 amperes. The motor is located near the top of the housings, geared to a countershaft, which in turn is belted to the driving pulleys. It is instructive to learn that the reverse to cut consumed (of course for an instant only) from 2.22 to 2.29 times the power required to cut; and the reverse to return from 4.95 to 3.59 the power required to return; or from 5.11 to 3.86 the power required for cutting. There were two tools cutting on cast steel crank webs.

The third experiment was with a 36-inch x 25-foot Putnam lathe, Crocker-Wheeler motor, 7.5 I, shunt-wound, 7.5 horse

power, 875 revolutions, 470 volts and 13.5 amperes; cutting shaft nickel steel, oil tempered and annealed, with Sanderson self-hardening steel tool.

The fourth and last experiment was with the same lathe, 36-inch x 25-foot Putnam, cutting nickel steel shaft, cut constant at $\frac{1}{4}$-inch deep and feed $\frac{1}{8}$-inch per revolution. The speed of motor was gradually increased from No. 3 notch to No. 11 notch of the controller, representing an increase of motor revolutions from 220 to 700 per minute. The results are given in the following table and are also plotted in Fig. 10.

Controller Notch.	Depth Cut.	Feed.	Amperes	Volts.	Revs. Motor.	Watts.	H. P.
3	$\frac{1}{4}$	$\frac{1}{8}$	6.3	126.5	220	796	1.068
4	$\frac{1}{4}$	$\frac{1}{8}$	6.1	156	277	950	1.276
5	$\frac{1}{4}$	$\frac{1}{8}$	7.6	197	343	1500	2.01
6	$\frac{1}{4}$	$\frac{1}{8}$	7.3	213.5	428	1560	2.092
7	$\frac{1}{4}$	$\frac{1}{8}$	8.3	262.5	540	2182	2.92
8	$\frac{1}{4}$	$\frac{1}{8}$	7	290.5	573	2035	2.73
9	$\frac{1}{4}$	$\frac{1}{8}$	8.3	334.5	655	2780	3.73
10	$\frac{1}{4}$	$\frac{1}{8}$	7.1	375	674	2675	3.57
11	$\frac{1}{4}$	$\frac{1}{8}$	8.4	378	700	3180	4.26

It is unfortunate that there was not time to carry these experiments still further, that correct deductions might be made as to the actual power required to cut various metals at varying speeds for different types of machines. Those shown are hardly sufficient in themselves to determine this data with any degree of exactness; still it may complete or add to somebody's information, while they in their turn may supplement ours.

As a general deduction it would seem that the tendency is to place too large motors upon the machines to the sacrifice of efficiency, as they are seldom, if ever, run at their highest speeds. It is, of course, best to have motors of ample size, but we are so fearful of getting them too small that we err on the other side. Necessarily in a shop manufacturing general machinery of all sizes and description, motors for a certain lathe must needs be larger than in a shop manufacturing standard engines, etc. In the first case the lathe may be called upon to turn up work of all diameters, while in the second instance the diameter of the work will vary within the same limits, year in and year out. These factors must be taken into account in designing an economical plant. We hope to have the pleasure of putting before our readers in

DATA FROM FIRST EXPERIMENT.

	Depth Cut.	Feed per Rev.	Turns per min.	Diameter Work.	Amperes.	Volts.	Revs. of Motor	H. P.	Watts.
1. Cutting	$\frac{1}{8}$''	$\frac{1}{16}$''	$2\frac{1}{4}$	$36\frac{1}{2}$	3.4	$222\frac{1}{4}$	353	1.15	756
					Back gear connected.				
2. Not Cutting	..	..	..	..	1.8	228	...	.694	578
					Back gear connected.				
3. Light	..	..	..	..	1.6	228	...	.49	364
					Back gear disconnected.				
4. Cutting	$\frac{1}{8}$	$\frac{1}{16}$	$2\frac{1}{5}$	42	3.4	221	346	1.07	757
					Back gear connected.				
5. Cutting	$\frac{1}{8}$	$\frac{1}{16}$	$3\frac{1}{4}$	41	3.65	$310\frac{1}{4}$	510	1.52	
					Back gear connected.				1135

Ratio.—Revolutions lathe spindle to motor, 1 to 157.
Metal removed per hour, No. 1 experiment, 33,8 lbs.
" " " " No. 4 " 38.2 "
" " " " No. 5 " 54.8 "

DATA FROM SECOND EXPERIMENT

	Depth Cut.	Feed.	Speed Cut per min.	Speed Reverse per min.	Revs. of Motor.		Amperes.	Volts.	Watts.	H. P.
1. Cutting, two tools.	$\frac{1}{8}$	$\frac{1}{16}$	17.15	60	423	Reverse to cut....	15	237	3560	4.77
						Cutting.........	6.75	237	1602	2.15
						Reverse to return.	34.75	236	8210	11.
						Returning........	7	236	1655	2.22
2. Cutting..........	$\frac{1}{8}$	$\frac{1}{16}$	21.83	68.6	544	Reverse to cut....	16	304	4860	6.52
						Cutting.........	7	304	2160	2.85
						Reverse to return.	27	304	8210	11.
						Returning........	7.5	304	2282	3.06
3. Not Cutting.......	..	..	17.15	60	424	Reverse to cut....	16	238	3810	5.41
						Cutting.........	4.5	238	1072	1.437
						Reverse to return.	33	238	7790	10.45
						Returning........	6.5	236	1536	2.06
4. Not Cutting......	..	..	21.83	68.6	560	Reverse to cut....	16	304	4860	6.52
						Cutting.........	5	304	1522	2.04
						Reverse to return.	27	304	8150	10.95
						Returning........	7.5	304	2285	3.06

DATA FROM THIRD EXPERIMENT.

	Depth Cut.	Feed per Rev.	Diameter Work.	Revs. per min.	Amperes.	Volts.	Revs. of Motor	H. P.	Watts.
1. Cutting	$\frac{5}{32}$''	$\frac{3}{64}$''	$9\frac{5}{8}$	$3\frac{9}{16}$	4	138.5	$258\frac{1}{2}$	.743	554
					Back gears connected.				
2. Not Cutting	..	..	..	4.13	1.35	150	300	.272	202
					Back gears connected.				
3. Light	..	..	..	4.25	1	152	308	.204	152
					Back gears disconnected				
4. Cutting	$\frac{1}{8}$	$\frac{1}{8}$	$9\frac{3}{4}$	5.76	5	226	418	1.516	1130
					Back gears connected.				
5. Cutting	$\frac{3}{16}$	$\frac{1}{8}$	$9\frac{3}{4}$	4.65	6.7	195.5	337	1.76	1310
					Back gears connected.				
6. Cutting	$\frac{1}{4}$	$\frac{1}{8}$	$9\frac{3}{4}$	3.28	7.3	194	238	1.9	1418
					Back gears connected				
7. Cutting	$\frac{1}{4}$	$\frac{1}{8}$	$9\frac{3}{4}$	2.71	8	117	$196\frac{1}{2}$	1.256	936
					Back gears connected.				

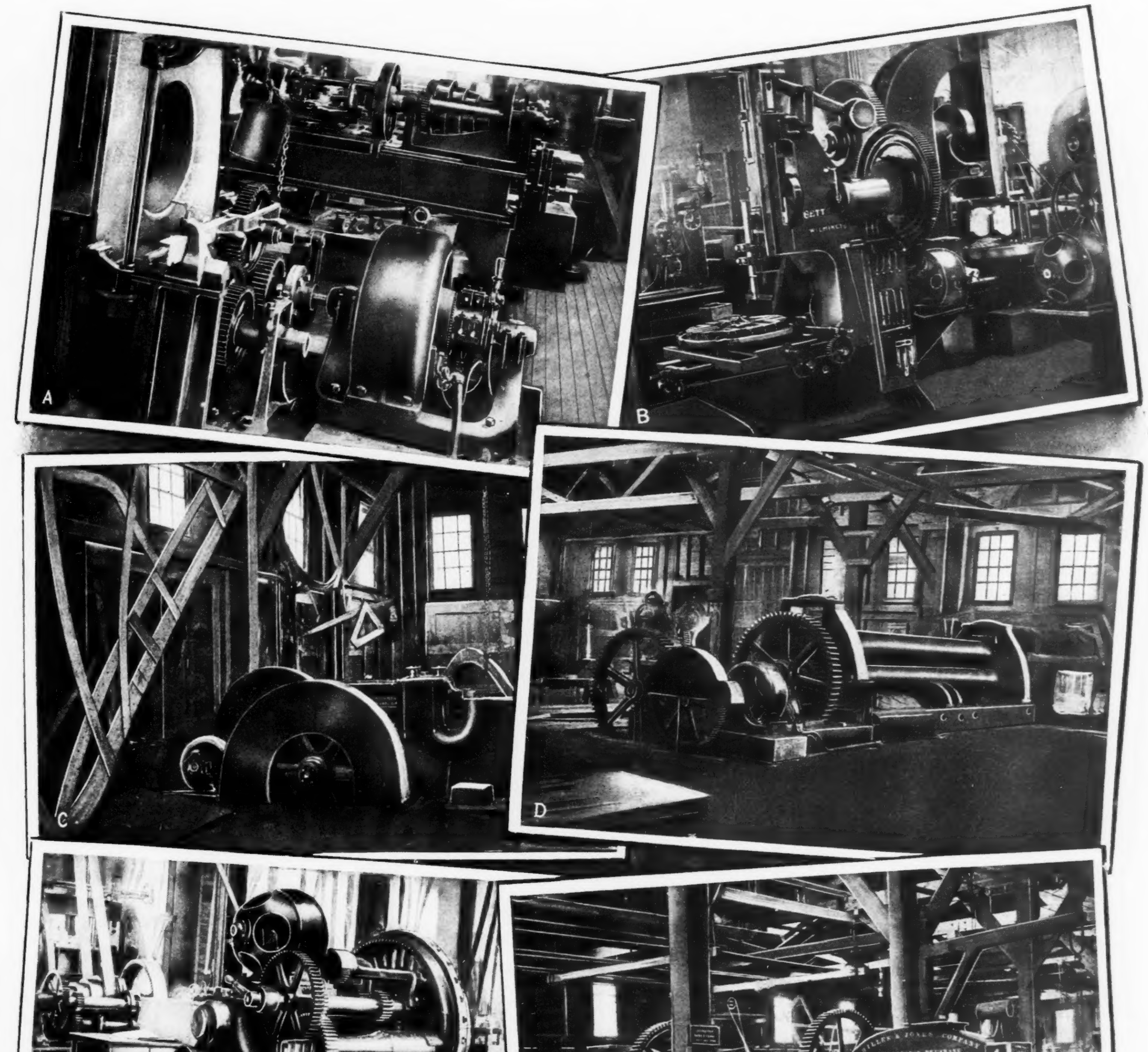


Fig. 9.

A.—Motor Drive for No. 7 Betts Boring Mill, 15 H. P. Motor.
B.—Betts 14-inch Slotter, 5 H. P. Motor.
C.—No. 3 Horizontal Punch, 7 1-2 H. P. Motor.
D.—Four 22-foot Bending Rolls—Driving, 35 H. P. Motor; Lifting, 10 H. P. Motor
E.—62-inch x 30-feet Putnam Lathe, 10 H. P. Motor.
F.—No. 4 Punch, 10 H. P. Motor.
G.—Back View 36-inch Putnam Lathe, 7.5 H. P. Motor.
H.—51-inch Baush Boring Mill, 7.5 H. P. Motor.

the future a systematic series of experiments of the capacities of type machine tools, under varying conditions, with tools of varying standard steels.

The table below gives a list of the principal tools, with their motors, as used in the machine shop.

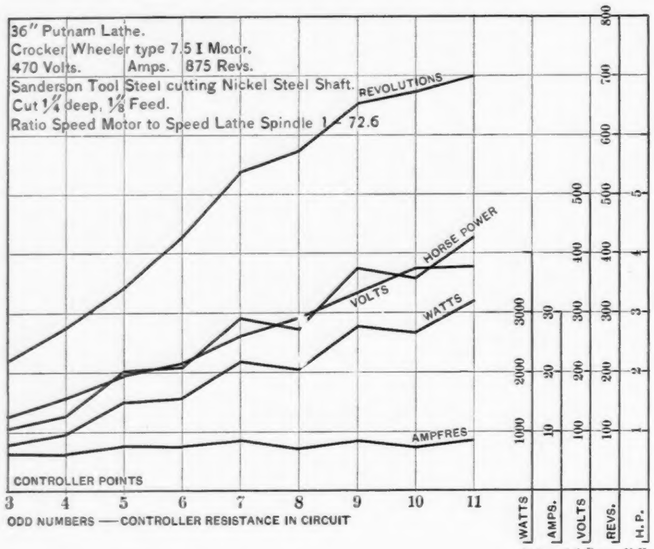


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Fig. 10. Diagram showing Results from Fourth Experiment.

Power Required to Drive Shafting.

A paper read at the International Engineering Congress at Glasgow in 1901 by Messrs. James Crighton and W. R. Riddel contains some figures that are interesting in connection with our desire to learn the amount of friction and power necessary to drive line and countershafting. There were two main lines of shafting in the case under discussion. At the first trial, only the line shafting and loose pulleys were run. The machines and countershafts were run along with the shafting at the second trial and the final trial was made with the machines cutting at their normal rate. The average diameter of shafting was 3¼ inches; the average number of revolutions 140 to 150; the bearings were of white metal, self-oiling. The machine was 12 feet between centers. The total length of shafting in the works was 2,300 feet and its weight 37.42 tons of 2,240 pounds.

The engine indicated 61.75 I. H. P. on the first trial; 141 I. H. P. on the second trial, and 310 I. H. P. on the third trial. From these powers it will be seen that the line shafting absorbed 29.3 per cent. of the total power; the machine and shafting 67 per cent, and that only 33 per cent. was applied to the removal of the material by cutting, planing, shaping, etc. These figures show the large proportion of power that is lost in keeping the system in motion and the absolute need of individual motor drives; for if but one or two machines are being used, this percentage of loss would be much greater, as this main line shaft friction is a constant quantity whether one machine or the machinery of the entire plant is being operated.

It will be understood that every machine need not be separately driven, as in many cases it is preferable to use the group system—that is, the use of a 15 or 20 horse power motor, driving several medium or small tools. This necessitates a short length of line shafting, but the friction is so small and the convenience so great that it is by far the best way. Another reason is that we have the advantage of the better efficiency of the large motor as compared with the lesser efficiency of the small ones. The cost is much less also, as we have one motor against five or six small ones.

* * *

EFFECTS OF ALUMINUM ON IRON AND STEEL.

The effects that small amounts of aluminum have on the different forms of iron are of great importance. It was discovered by Wittenstrom in the 80's that, if 0.05 to 0.1 per cent of aluminum was added to a charge of wrought iron heated to pastiness, the iron liquefied so that it could be poured. The castings called Mitis castings have properties similar to wrought iron, excepting that they lack the fibrous structure.

In making steel castings, an addition of 0.03 to 0.05 per cent. of aluminum has a very beneficial effect in reducing the small amounts of iron oxide that are formed, especially in pouring. The elimination of oxides makes the steel more tough, and by preventing the oxides from oxidizing some of the carbon of the steel, it hinders the evolution of carbon monoxide, which, stirring up the steel, causes the expulsion of occluded gases. It thus diminishes, if it does not prevent, the formation of blow-holes.

The effect of 0.01 to 0.05 per cent. of aluminum upon cast iron is to convert some of the combined carbon into graphitic carbon. It is mentioned here in connection with wrought iron and steel as the third form of industrial iron. A satisfactory explanation has so far not been offered.—F. O. Hofman in *Technology Quarterly*.

SPECIFICATIONS OF PRINCIPAL TOOLS, AND THEIR MOTORS.

MACHINE.	Size.	Motor.	Size.	H. P.	Revs.	Volts	Amperes.	Winding
Cincinnati D. H. Shaper	18"	C.-W.	3 I	3	975	470	5.75	Comp.
Pond Boring Mill	10'	C.-W.	20 D	20	775	470	36	Shunt
Newton Slotter	18"	C.-W.	7½I	7½	875	470	13.5	Comp.
Baush Radial Drill	No. 6	C.-W.	5 I	5	950	470	9.4	Shunt
Radial Drill	5'	C.-W.	5 I	5	950	470	9.4	Shunt
Newton Slotter	14"	C. W.	5 I	5	950	470	9.4	Comp.
Woodward & Powell Planer	36" x 12'	C.-W.	15 I	15	840	470	28	Comp.
" " "	36" x 12'	C.-W.	15 I	15	840	470	28	Comp.
" " "	36" x 16'	C -W.	15 I	15	840	470	28	Comp.
Gray Planer	56" x 56" x 12'	C.-W.	20 I	20	775	470	36	Comp.
Woodward & Powell Planer	30" x 30" x 8	......	10 I	10	850	470	18.5	Comp.
Mitts & Merrill Keyseater	No. 5	C.-W.	3 I	3	975	470	5.75	Comp.
Newton Cold Saw	......	C.-W.	5–I	5	950	470	9.4	Comp.
Newton Floor Boring Machine	No. 1	C.-W.	7.5 I	7.5	875	470	13.5	Shunt
Newton Duplex Rod Boring Mill	......	C.-W.	1	1	950	470	2	Series
......	......	C.-W.	7.5 I	7.5	875	470	13.5	Shunt
Shaft Lathe	38" x 44'	C.-W.	7.5 I	7.5	875	470	13.5	Shunt
Newton Duplex Boring Machine	......	C.-W.	7.5 I	7.5	875	470	13.5	Shunt
Niles Horizontal Boring Machine	......	C.-W.	15 D	15	800	470	28	Shunt
Duplex Milling Machine, Newton	No. 4	C.-W.	10 I	10	850	470	18.5	Shunt
Doublehead Shaper	......	C.-W.	3 I	3	975	470	5.75	Comp.
Betts Boring Mill	7'	C.-W.	....	½	1200	470	1.1	Series
" " "	7'	C.-W.	15 D	15	800	470	28	Shunt
Betts Slotter	10"	C.-W.	3 I	3	975	470	5.75	Comp.
Baush Boring Mill	51"	C.-W.	7.5 I	7.5	875	470	13.5	Shunt
Acme Bolt Cutter	No. 1	C.-W.	7.5 I	7.5	875	470	13.5	Shunt
Planer	42" x 42" x 20'	C.-W.	15 I	15	840	470	28	Shunt
Dallett & Co. Portable Deck Planer	......	......	....	5	...	470	7	......
Putnam Lathe	62" x 30'	C.-W.	10 I	10	850	470	18.5	Shunt
" "	36" x 25'	......	7.5 I	7.5	875	470	13.5	Shunt
For Boring out Shaft Struts	......	C.-W.	7½ I	5	975	470	9.3	Comp.

STEEL AND ITS TREATMENT.—1.

HEATING FOR HARDENING.

E. R. MARKHAM.

If men engaged in the different branches of shop work would perfect themselves in their particular lines, and in this way convince those who employ them that they are proficient workmen, they would, by so doing, make themselves indispensable.

"But," said one young man to whom I was talking about taking up a course of evening study, "I work hard all day and I don't care to study all night. When I get out at six o'clock I want a little recreation; so I go down town with the boys. I shan't be young but once you know." I told him he would be old once, and asked him to seriously consider this fact and that the money he spent evenings with the boys would purchase the necessary books to study; or would pay for a course of study in some correspondence school. His answer was: "I never spend more than 10 or 15 cents of an evening, and that is little enough. Why, Smith spends from 25 to 50 cents every night, and I could tell you of lots of boys in our crowd who spend *more* than that." And he tries to justify his own actions by mentioning others worse than himself.

An experience of years in charge of large numbers of men has convinced me that it is not of much use to talk to the "*old fellows*" whose habits are fixed. I wish to say a few words to the *young man* just starting to learn the trade that is to fit him to fight life's battle; and to the man—be he young or middle aged—who has an ambition to be somebody, and realizes that he depends on his own efforts to reach the goal. And by the way, when it is apparent that a man is trying to help himself, some one is generally found who will take an interest in him and try to help him. I hear young men say: "What is the use of studying and working every minute trying to reach the top of the ladder? If everyone did that, the top wouldn't be large enough to hold them all." As long as a great proportion of our young men feel and talk that way, however, there is no great danger that the top rounds of the ladder will be seriously affected by the weight they have to sustain. And the chances are good for the man who is willing to sacrifice a little time each week in order to broaden his mind and learn things that will be of benefit to him in the future.

At the present time when libraries are accessible to nearly everyone, and when books and mechanical journals treating on nearly every branch of the machine business can be obtained so cheaply, there is really no excuse for the man who does not better his condition. And in no branch of machine shop work is there a greater field for study and advancement than in that of hardening and tempering steel.

The past twenty-five years has witnessed great changes in the designing of machinery. Lathes, planers and milling machines have been changed not only in design but by the addition of metal to so strengthen them that heavier cuts can be taken and faster feeds used than were dreamed of thirty years ago. Now in order to have these machines do the maximum amount of work it has been necessary to make stronger and heavier fixtures. Cutting tools have also been changed and made much stronger. But if these tools are to do the amount of work the machines are capable of producing, it is very essential that they be hardened *properly*. I am convinced that very few manufacturers realize the amount of money lost in their establishments every month because cutting tools are not properly hardened, and are thus incapable of turning out as much work as they otherwise might. Some manufacturers are looking for men who can do this class of work in a *satisfactory* manner; and their number will increase as they realize the enormous leak through this one source, and the demand for competent hardeners will be greater than the supply.

In order to become a successful hardener, one must understand the characteristics and the nature and peculiarities of steel. These can best be learned by an intelligent study of works treating on these subjects. Tool steel is manufactured with the idea in view that it is to be used to make tools that must be hardened in order to do the work expected of them. All makes of tool steel are not adapted to the same class of tools. Many times a mistake is made in buying steel, say, to make fine-edge tools, because some one had good success with this particular make when using it for railroad track chisels. As the man using the steel has very little to say about the buying of it, I shall not say what particular brand of steel is best for this or that purpose; but I shall endeavor to give the reader such advice as should enable him with a little practice to get good results from almost any make of steel.

Any tool steel commonly used in machine shop work has a surface which is somewhat decarbonized from the action of the oxygen in the air acting on the carbon near the surface of the bar, during the various processes through which it goes, in the rolling mill and forge shop. Consequently it is necessary to select steel enough larger than finish size of the tool to be made, to allow of the removal of sufficient stock to get below this portion, or the piece when hardened will have a *soft* surface. Or if not soft the surface will not be as hard as the balance of the piece. When centering tool steel it is necessary to have the centerpunch mark in the *center* of the piece, as indicated in Fig. 1. If centered as

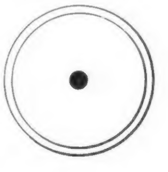

Fig. 1.

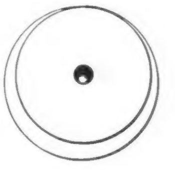

Fig. 2.

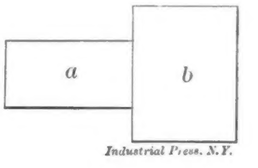

Fig. 3.

shown in Fig. 2 a larger portion of the decarbonized surface will be removed at *a* than at *b*. As a result the side from which the greater amount of stock was removed will be the hardest; and as steel contracts when hardening, if one side is harder than the opposite side, the contraction of the two opposite sides will be unequal, consequently the piece must spring.

Every man and boy working in a machine shop knows that tool steel is hardened by heating until red hot and then plunging in some cooling bath. But a great many are not thoroughly posted as to the best methods of procedure to get the best results. In order to heat steel properly one must understand the peculiarities of the particular steel he is using. All steels are not affected alike by the action of heat. Some makes of steel will harden at an extremely *low* red heat, and give the best results if heated in this manner; while others require a higher heat in order to harden at all. One brand of steel I have in mind gives excellent results if heated for hardening in some manner that excludes the air from the steel; but if a tool which cannot be ground on its outer surface—as a tap or formed milling cutter—be made of this steel and exposed to the action of the air when heating, the surface carbon will be given off to such an extent that the outer surface will be soft, rendering the tool unfit for use. Yet these same tools if heated in a muffler furnace, or in a piece of gas pipe, or tube, in the open fire would be very satisfactory. In fact, *any* steel is better if heated for hardening as described above; but all steels are not so sensitive to the action of the air as the one mentioned.

I remember having in my employ in a large tool room at one time, a young man who, when he had a tool to make whose shape betokened trouble in hardening, would ask permission to harden the tool himself. This privilege was always granted, as he showed a desire to learn. While the machine at which he was working was running, he would cut a thin piece of steel from the end of the bar from which he had cut the piece for the tool. This he would heat in a furnace in the tool room and then harden, being very careful in heating not to get it any hotter than was necessary, according to his judgment. After drying thoroughly he would examine it for hardness. If he considered it hard enough he would break it and examine the fracture.

He would then bring it to me and tell me his opinion of the steel and of his heat, asking me to give him any information possible on the subject. Is it necessary for me to say

that to-day that young man is holding a responsible position in a large manufacturing establishment? The desire he had to know the *whys* and *wherefores* of every job he had anything to do with, gave him an impetus to study and work, and it was a positive pleasure to give him any information possible.

But to return to the heating of steel for hardening. Although steel should never be given a higher heat than is necessary to produce a desired result, an uneven heat is much more detrimental to steel than an even heat which is a trifle too high. In order to get good results when hardening, the piece must be heated uniformly throughout, the corners and edges must not be hotter than the center, and the interior of the piece must be of the same temperature as the outside; otherwise the piece will be almost sure to crack when dipped in the hardening bath. If a piece of steel is heated hotter than is advisable for hardening—yet not hot enough to burn it—lay it one side, and allow it to cool. Then it may be reheated to the proper temperature and plunged in the bath. The effect of a high heat is to open the *grain* of the steel, making it porous. In this condition it is very brittle, and on account of the separation of the atoms that go to make up the piece of steel, it will be incapable of doing the amount of work it would if the grain were compact, as the minute holes or pores between the atoms of steel allow the surface of the tool to break away. The reheating of the piece has the effect of closing the pores and of making the grain compact, thereby furnishing a solid backing for the cutting edge.

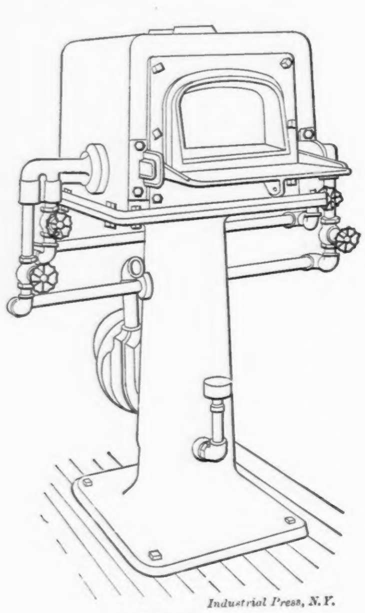

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Fig. 4.

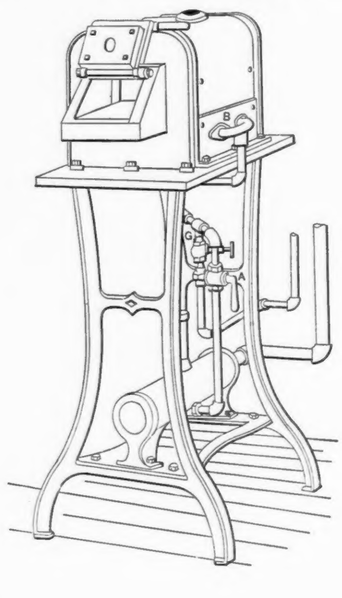

Fig. 5.

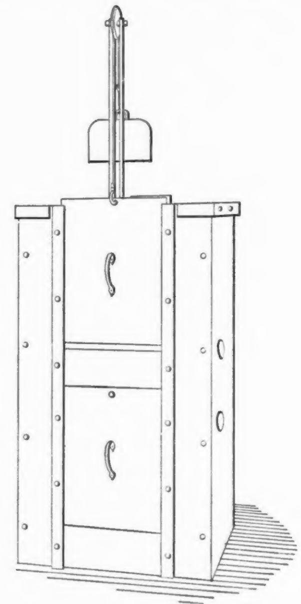

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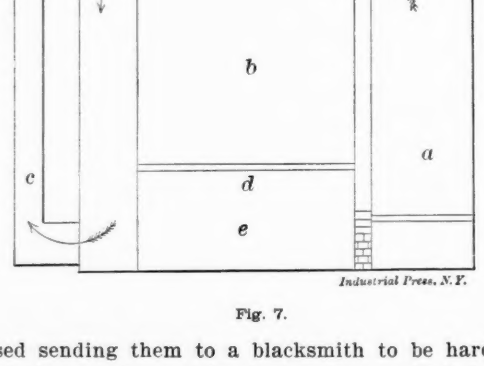
Fig. 6.

A method that is wrong, but nevertheless often adopted by shop men when a tool is heated too high, is to allow it to cool in the air until it appears "about right" and then to dip it. The grain is then as open as if dipped at the high heat, and the unequal heat—too hot inside and cooler at the surface—would cause unequal contraction of the outer and inner portions of the piece, thereby causing it to crack. It is *unequal* contraction when cooling that causes a tool of the shape shown in Fig. 3 to crack at the shoulder when hardened. Heat has the effect of expanding steel, while cooling contracts it. A piece of steel which is expanded by heating, if suddenly cooled (and thereby contracted) is subjected to a very great strain. Now if one portion of Fig. 2, as *a*, is smaller than *b*, then *a* will, of course, contract faster than *b*. And if *a* hardens way into the corner or to the shoulder before the larger portion was through contracting a crack must be the result. This would be especially true if the two diameters were unevenly heated. But the larger shoulder containing more heat than the smaller diameter communicates *its* heat to the corner, keeping that from cooling as rapidly as the balance of the smaller portion and preventing cracking at that point. Uneven heating is probably the cause of more steel being ruined than any other one thing. While it is advisable to heat steel as quickly as possible consistent with uniform heating, yet it should never be heated so fast as to produce uneven heats.

It is, of course, very desirable to have in a hardening room the best equipment obtainable. Generally speaking, however, men are obliged to use the equipment furnished by the concern employing them. Everything being equal, a man having access to a good muffler gas furnace, and the most approved baths can do better work than one who is obliged to use an ordinary blacksmiths' forge having a leaky tuyere, and whose only bath is a greasy pail filled with water of an uncertain quality. Yet it is a fact that the *successful* men in our shops are men who make the best of conditions as they find them. Now, if a man finds the conditions as stated, he can build a large, high fire, and by placing the article to be hardened in a piece of pipe or other receptacle, so that the fire and air from the blast cannot strike it, he can by frequently turning and moving the piece, get a very uniform heat. He can also empty the pail, wash it out and fill it with clear water. Years ago I was making tools in a small shop that had just been started, where there was no furnace of any description and no means of heating a piece of steel. I made six sets of small form milling cutters. The proprietor



Industrial Press, N.Y.

Fig. 7.

proposed sending them to a blacksmith to be hardened, but I asked the privilege of hardening them, which he granted. I took them home, and heated them in the kitchen range, putting them one at a time in a small iron box I had in the house. I placed about ½ inch of powdered charcoal in the box before putting in the cutter and while the cutter was heating I covered the box with a piece of sheet iron. When the cutter had reached an even low red heat, I took it from the box with a hook and plunged it in a pail of water containing a small quantity of salt. After hardening the entire lot they were brightened and the temper drawn. In order to do this I inverted the box in the fire, placed the cutters on the bottom of the box, and by frequently turning them I got a very satis-

factory temper, as they were not very thick. I mention this incident to show that under trying circumstances a man may, by using his wits, do a very satisfactory job. Although I have since then hardened many pieces worth hundreds of dollars each, I do not think I have ever done a job of hardening that was a source of greater pride than those milling cutters, hardened under the difficulties mentioned.

The heating of steel is very important and a great deal depends on the facilities for doing a good job in a reasonable amount of time. There are several forms of hardening furnaces in the market which give excellent results. Figs. 4 and 5 show two kinds using illuminating gas as fuel, which are both of the form known as muffler furnaces, because the work is heated in an oven, or muffler. The flame circulating around the muffler does not come in contact with the steel and one obtains much better results than if the work were exposed to the action of the products of combustion in the fire. But if so situated that one cannot have a furnace of the kind shown, it is possible to make one that will do excellent work. Still I doubt the economy of making one when it may be bought so cheaply of some reliable maker.

If the gas rates are reasonable in the city in which the shop is located, a gas hardening furnace will be found the cheapest form to use. They are certainly the most satisfactory. But if the gas rates are so high as to make this sort of furnace impracticable, a very excellent form of coal-burning furnace, of the form shown in Fig. 6, may be procured, or one as shown in Fig. 7 may be used. This furnace will burn either charcoal or hard coal. It consists of a firebox *a* and a muffler *b*, the flame and heat passing up the side and across the top of the muffler in the direction of the arrow. It then passes down the opposite side of the muffler to the smoke pipe *c*. The grate *d* should be made of a form that allows of the easy removal of clinkers and ashes. The ash box *e* should be provided with a door having draft holes, which may be closed or opened to furnish the desired amount of draft. There should also be a damper in the smoke pipe in order that the draft may be checked at will. The muffler should have a door, through which should be drilled one or two holes. These should be covered with isinglass, in order to exclude the outside air, yet furnish a means whereby the condition of the work may be seen when the door is shut.

It should be borne in mind that it is not advisable to heat tool steel in an ordinary *coal* fire unless some means is provided whereby the fire will not come in contact with the steel, as the sulphur in the coal has a very injurious effect on the steel. In the furnace described above, the work being in the muffler is entirely removed from the action of the fire, the heating being done by radiation.

A piece of tool steel that is to be hardened should never be straightened *cold*. If the piece is bent too much to turn out and allow of removing all the decarbonized portion at all points, it should be brought to a red heat and straightened. If a piece of stock should spring in annealing it should not be straightened *cold*, that is, if it is to be hardened afterward.

When making costly tools from a bar of steel that has not been tested, it is advisable to cut a small piece of stock from the bar, heat it very carefully, dip in the bath, and then test it with a file for hardness. After drying thoroughly it should be broken as nearly across the center as possible, the grain examined, and by aid of a magnifying glass it should be examined also for traces of piping. If the steel is piped the bar should be returned to the steel mill before there is any chance of an expensive tool being made from it.

"A pipe," according to Metcalf, "is the cavity formed in an ingot when it cools; the walls chill first and nearly to the full size of the mold, then the shrinking mass separates in the middle, forming a pipe. A pipe should be at the top of the ingot; it may occur anywhere by bad teeming. This cavity, or pipe, may extend through the entire length of the bar, rendering it unfit for general use. A make of steel should not be condemned, however, because a bar containing a pipe is discovered. This is liable to happen to any steel. It is closely inspected at the mill, but sometimes escapes even the closest inspection, and the steel maker will willingly replace the piped steel with a sound bar.

BLANKING DIES.

MAKING AND USING "DOUBLE" OR PIERCING AND BLANKING DIES.

JOSEPH V. WOODWORTH.

When ordering steel for dies, annealed steel should be specified, as the saving of time and labor and the superior results that will be obtained in hardening and tempering the finished tools will be a source of gratification to the diemaker. When these results are taken into account the slight extra cost of annealed steel is insignificant. As to the grade or brand of steel to use, be sure to get a good grade, and as there are several brands of steel on the market which are used principally for dies, no difficulty should be experienced in procuring a grade which will prove suitable for any special class of work. When steel forgings are required the job should be given to a smith who understands this branch of his art, for, in order that the forgings shall machine well and be hardened and tempered so that the finished tools will work satisfactorily, the smith must understand such work.

Die Block or Bolster.

Before taking up the description of the die we will devote a short space to the die block or bolster. Although these bolsters are made in a variety of shapes and sizes, the one shown in Fig. 1 is of the type most generally used for fastening and locating the class of dies indicated, while in Fig. 2 are shown a number of other styles used for dies of the same class. A large number of shops make a bolster for each die, so as to leave the tool permanently within it, but for economy, where dies for producing blanks of an average shape and size are used, two or three are all that are required.

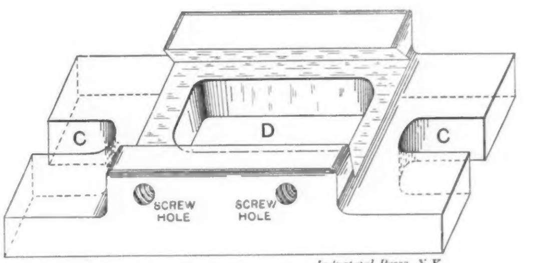


Fig. 1. Bolster for Holding the Die.

In machining the bolster a cut should first be taken off the bottom and then the face planed dovetail to an angle of 10 degrees, this being a standard among diemakers. The slots *C C*, Fig. 1, are cast in width sufficient to allow of clearance sideways for the fastening bolts, with which it is afterward secured to the press bolster. The hole *D*, in the center, should be made large enough for the largest blank—from the set of dies which are to be used in this bolster—to drop through after being punched.

Double Punch and Die.

In Figs. 3, 4 and 5 are shown a double punch and die used for the production of blanks like Fig. 6. The punch and die consist of the following parts: The punch holder or stem *A*, Fig. 4, of cast iron, the punch plate or pad *B* of mild steel, the blanking punch *C* of tool steel, the piercing punches *D* of the same, the stripper and gage plate *E*, the die *F* of tool steel and the pilot pin *G*. The shape of the piece to be produced in a die of this type may be any circular or irregular shape desired, as the method of construction here described is applicable to all, excepting when the blank to be produced is very large in size or when the metal punched is very thick. Fig. 8 shows different shaped blanks produced in dies of the above construction.

As most presses in which punches and dies of this class are used require a punch-holder with a round stem, one of this sort is here shown. When machining the holder great care must be taken to get the working surfaces square with the stem; also the faces of the punch plate and stripper plate must be perfectly parallel. When planing the die no great care is required, as it has to be ground after hardening. It should be finished with beveled sides to fit the bolster, with the edges of the face smooth, so as to have a square edge

from which to lay out the die. Lay the punch plate, punch-holder and stripper plate aside, as they will not be touched until the die proper has been finished.

The Use of Templets.

Now in order to lay out the die a templet or master blank is required. It should be made from sheet steel about 3-32 inch thick, and should be filed and finished all over to the exact shape of the blank and be the size required. The two holes should then be laid out in the exact location desired, and then drilled and reamed to size. Care and accuracy in the preparation of the templet are necessary, as the quality of the work to be produced depends on it. Now take a piece of, say, ⅛-inch brass rod about 2 inches long and solder one end of it to the back of the templet as shown in Fig. 6. The templet is now complete and there is no possibility of getting the wrong side up.

Take a piece of soft sheet brass, of the same thickness as the male templet, and bend it to the shape shown in Fig. 7; that is, to fit across and over the face of the die, with the bent ends projecting down the inclined sides of the die about 5-16 inch. This is the female templet, and it should be worked out in the center to fit the male templet. After this has been done the face of the die should be polished with rough emery cloth and "blue-stoned," the female templet placed upon it, in the proper position, and an outline of the blank marked through it on the face of the die with a sharp scriber. Now remove the templet and proceed to finish the blanking die, which is accomplished by working the blank through it.

To work a templet through a die proceed as follows: After the surplus stock has been removed by drilling holes about 1-32 inch apart around the inside of the outline and then drifting it out, file through from the back to within a shade of the line. Now take the male templet and, holding it by the end of the brass rod, enter it into the die from the back, holding it as parallel as possible with the face of the die. By holding a piece of white paper in front of the die it will be seen that the die touches the templet at only a few narrow spots. Take a lead pencil and mark these spots, making a line at each spot as long as the surface touched. Now remove the templet and file where the marks appear. Keep inserting the templet, marking the spots, and filing them away, and in a surprisingly short time the templet will be at the top of the die, which will then be the exact shape and size desired, fitting the templet perfectly.

Clearance.

There are a great many dies of this type used (for blanking out stock which is not required to have smooth sides) in which it is not necessary to finish the insides smoothly; but there are a greater number in which the finish of blanks with smooth sides is one of the objects sought. In dies for producing smooth and well-finished blanks the insides should be finished highly, either with a dead smooth file or a scraper.

In giving clearance to a die a few things must be considered in order to decide upon the proper amount to give. For a die which will only be used to produce a few thousand blanks excessive clearance should be given, say, 5 degrees, as this will allow of the die being finished quickly. In dies which are required to produce large quantities of blanks, and in which the blanks produced are desired to be approximately the same shape and size, 1 degree is plenty. As the die will have 1 degree of clearance all the way through, the holes drilled in the process of removing the stock should be reamed from the back with a reamer tapered to from about 1-32 inch to 1 inch of length. The reaming of the holes when constructing a blanking die will save a vast amount of filing, and the giving of the 1 degree of clearance will not be difficult.

The next step in the construction of the die is the locating of the two piercing holes. To accomplish this, place the male templet within the female and clamp it to the face of the die in the correct position, allowing for a thickness of metal between the blanks. Now take a center drill which fits the holes in the male templet and transfer the two holes through it to the face of the die. Drill these holes and then ream them from the back with a reamer of the same taper as the one used for the blanking die. After the holes for the dowel pins and screws, with which the stripper and gage plate are to be located and fastened on the die face, have been drilled and tapped and the hole for the stop pin located and drilled the die is ready to be hardened and tempered.

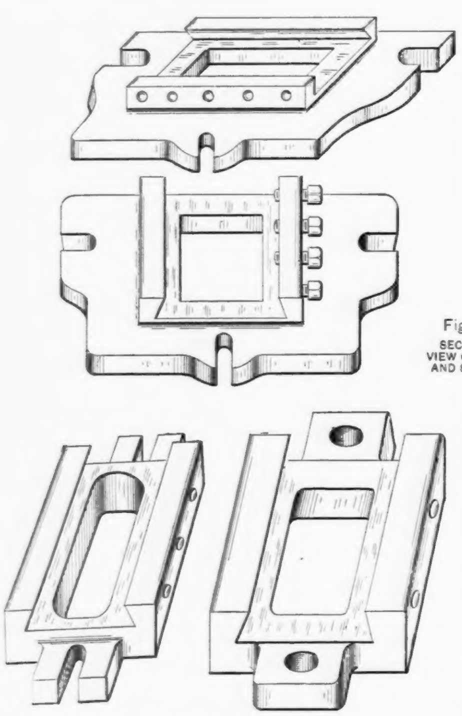
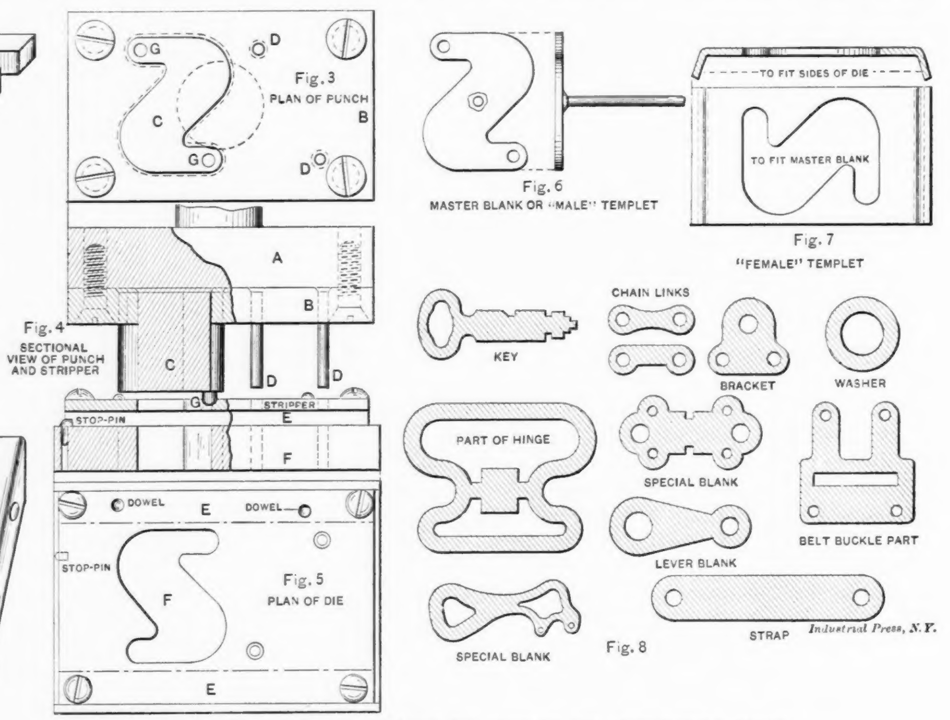


Fig. 2. Different Types of Bolsters.



Figs. 3 to 8. Double Punch and Die, Templets and Characteristic Blanks.

Hardening a Blanking Die.

In order to harden a blanking die properly great care should be taken, first, in the heating of the steel, and, second, in the quenching. In all shops where dies or other tools that require hardening are constructed a gas furnace or "muffler" should be used for heating them. But when a "muffler" is not handy charcoal should be used. After a good clean fire has been built all screw and dowel holes should be plugged with fire clay or asbestos. By taking these precautions the tendency of the steel to crack around the holes is, as far as possible, eliminated. The steel is now heated to an even cherry red, so that the entire surface will be the same heat. Then it is removed from the fire and dipped straight down, endwise, into the water, which should first be warmed slightly to take off the chill. Care should be taken to dip straight and

not to move it or shake it around, as that will increase the possibility of the die warping or shrinking excessively. After removing the die from the water it should be immediately warmed. Now grind the face of the die, heat a piece of heavy cast iron red hot, place the die upon it, and it can then be drawn evenly to the temper desired. By taking a piece of oily waste and wiping the face of the die as it is heating the different colors will show up clearly. When the color denoting the temper required appears remove the die and allow it to cool off slowly.

Finishing the Punch.

Now for the blanking punch. Take the blank, or male templet, remove the wire rod and mark the spot where it was attached so as to know the back from the front of the blank. Then solder the blank, front out, to one end of the piece of steel which is to be used for the blanking punch. The punch can now be machined, either in the shaper or in the milling machine, so that its entire length will be the shape of the blank, finishing it as close to the edges of the templet as possible. Now heat the punch slightly and the templet will drop off. Clean the blank, lay it aside, and proceed to fit the punch. If it is to punch very thin stock make it a tight fit within the die; if for heavy stock, a trifle loose. In order to make a punch a perfect fit, so as to punch thin stock cleanly, the edges of the cutting face should be beveled with a file and the punch should then be sheared through the die in the press, in much the same manner as a broach is used, being careful to have it in perfect alignment with the die. This shearing of the punch should be accomplished progressively, first forcing it in about 1/8 inch, then removing it and filing away the curled up metal, and repeating this until the punch has been forced completely through the die. While doing this use plenty of oil on the parts.

Before hardening the punch—that is, if it is to produce accurate work, for in most cases it should be left soft—it is necessary to locate the holes for the pilot pins *G*. These pins are necessary in order to produce pierced blanks that will be interchangeable. Take the male templet and enter it into the die from the back, with the front up. It will fit the die tightly because of the shrinkage in hardening. Now enter the blanking punch from the top and locate the holes for the pilot pins through the holes in the blank with the same center drill used for locating the piercing dies. Drill the holes to size and then harden and draw the punch to the temper desired, which in most cases should be a dark blue. In tempering the punch draw it from the back, allowing the temper to run out to the face, and thus the back will be soft while the remainder will be as hard as required. The drawing of the punch so that the back will be soft is done to strengthen it and also to allow of upsetting it when locating it within the punch plate.

Aligning the Parts.

To locate the blanking punch in the punch plate, take the plate and clamp it true on the face of the die and then transfer the outline of the blanking die to the punch face. Then work a hole of the shape of this outline through the plate so that the punch can be entered face first through from the back. Place both punch and punch plate under the ram of the press, set the punch dead square with the face of the pad and proceed to force it through, using the punch as a broach to finish the hole. It will be found necessary to repeat this operation several times in order to get the punch through the plate, as the surplus stock curled up by the punch will have to be removed. After having forced the punch into the pad until the face is through, force it back and out again. Now chamfer the edges of the hole at the back of the plate and force the punch in again, until the back is a shade above the plate; then upset or rivet as shown and finish flat with the plate, and there will be no danger of the punch pulling out when in action.

To locate the holes for the piercing punches, enter the blanking punch into the die until the faces of the punch plate and the die are within 3-16 inch of each other, with a pair of parallels between them. Then use the die as a jig and locate holes for the piercing punches, spotting these deeply. With a drill about two sizes smaller than the piercing dies, drill entirely through the punch plate and then ream the holes to size. Use the die as a jig for all three operations. For the two piercing punches use drill rod or Stubbs wire and upset the heads before hardening, as all small piercing punches should be hardened for their entire length, otherwise they will bend or break when passing through the stock. If, after hardening, the punches are found to have sprung, they must be carefully straightened before forcing them into the punch plate. Fasten the punch plate to the cast-iron holder *A* with four flat-head screws, as shown in Fig. 4.

All holes for screws and dowels in the stripper plate should be transferred through the die. The holes for the two piercing punches should be the same size as the dies, and must be transferred, drilled and reamed through the dies after the plate has been located and fastened. By having the piercing punches fit tightly within the stripper they will be strengthened and supported while piercing the metal. The hole for the blanking punch may be a loose fit for the punch. After the gage plates and stripper have been located and fastened upon the die, as shown, with the stop pin located so that its locating face is the same distance from the edge of the blanking die as the width of surplus stock allowed between the blanks, the die will be complete.

The practical points to be kept in mind when constructing a die of the above type are: Be sure to make an accurate pair of templets. Machine the punch-holder, the pad and stripper plate accurately. Work the blank through the die and use it in locating all the holes for pilot pins and piercing dies. Finish the die before starting on any of the other parts. Transfer all holes in the punch plate through the die, and, lastly, be sure to have the front of the male templet up during all operations in which it is used. By keeping these practical points in mind you will have a punch and die in which the alignment between all parts will be perfect.

Setting the Die and Using it.

To operate the die drive it into the die block or bolster, Fig. 1, and then set it up in the press. The proper way to set a die of this kind is to first place the punch within the ram of the press and fasten it there. The punch should then be brought down until its face is within 3-16 inch of the die face. Then, using the left hand through the press bolster, the die should be raised up until all punches have entered it. The punch should then be brought down, by moving the press fly-wheel with the right hand, about 5-16 inch, and the die will rest squarely on the press bolster in perfect alignment with the punch. Now fasten the die to the press, give it a rap with a hammer at each end and go ahead.

The stock to be punched should be entered beneath the stripper and pushed up against the stop pin. At the first stroke of the press the two holes will be pierced and a "scrap" blank punched out. Now feed the stock forward until the back edge of the punched hole rests against the stop pin, and at the next stroke, as the punch descends, the pilot pins in the blanking punch will enter the holes pierced at the first stroke and a blank will be produced which will be an exact duplicate of the male templet. The stock may then be fed along until the entire strip has been worked up.

* * *

In astronomical work it is of the greatest importance to be able to read the graduated circles with the attached microscopes without bringing near the circles the source of light. Any light that we are now able to produce is accompanied by heat, and heat even of small degree locally applied, will quickly distort the circles so that accurate readings are impossible. To overcome this difficulty, Professor Becker, of Glasgow University, has recourse to solid glass rods to convey light to the graduated circles. Light projected into one end of a glass rod such as he uses, is delivered at the other end, even if the rod is curved. The light cannot escape from the sides on account of the internal reflection from the sides. The heat conveyed with the light, is, of course, of little proportions. To illustrate the sensibility of such graduated circles it may be mentioned that the radiation of heat from the human body has been found to exert a most sensible effect. So if it is necessary for an attendant to be near a circle, he or some one to take his place must remain in the same approximate position constantly throughout an observation.

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Entered at the Post-Office in New York City as Second-class Mail Matter.

MACHINERY

Design—Construction—Operation.

PUBLISHED MONTHLY BY

THE INDUSTRIAL PRESS,

9-15 MURRAY STREET, NEW YORK CITY.

CHICAGO—1462 MONADNOCK BLOCK. BOSTON—620 ATLANTIC AVE.
PHILADELPHIA—MACHINERY FLOOR, THE BOURSE.

SUBSCRIPTIONS.

SHOP EDITION, $1.00 A YEAR. TEN CENTS A COPY.
ENGINEERING EDITION, $2.00 A YEAR. TWENTY CENTS A COPY.
FOREIGN EDITION, $3.00 A YEAR PREPAID.

LESTER G. FRENCH, Editor.
FRED E. ROGERS and GEO. H. HALL, Associate Editors.

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We solicit communications from practical men on subjects pertaining to machinery, for which the necessary illustrations will be made at our expense. All copy must reach us by the 5th of the month preceding publication.

SEPTEMBER, 1902.

NET CIRCULATION FOR AUGUST, 1902,—25,724 COPIES.

Mr. George H. Hall has been engaged as Associate Editor on the staff of MACHINERY, his work beginning with the October number. This addition to the editorial force will enable us to materially strengthen the machine shop features of the paper and we shall make the dollar or shop edition more valuable to the practical machinist than ever before. Mr. Hall is well equipped for his position by technical training and some eight years' varied experience in machine shop and drafting room, as well as by occasional work which he has already done on MACHINERY.

* * *

EIGHT YEARS.

The eight years which comprise the life of MACHINERY cover a period of unexampled prosperity to manufacturers; and while the growth of the paper has been unusual in the history of trade publications, it has not more than kept pace with the progress of the trade it represents.

Firms that were not in existence eight years ago, to-day own and operate plants employing hundreds of men, the establishment of which heretofore represented the toil and saving of a generation, and the extension of existing plants has progressed in a like degree. One entire section of Cincinnati—a city in itself—devoted almost entirely to the manufacture of machine tools and comprising twenty-one plants, some of the largest in the country, has sprung up in the period referred to. And it is also true that the rewards of skill and energy during that period have not been limited to the employer; for among the writer's personal acquaintance are many instances of mechanics who were earning day's wages less than eight years ago, who now control enterprises which represent the investment of good-sized fortunes. Yet the development in machine tools and kindred lines in this country has hardly more than begun, for the multiplicity of enterprises which rely for their progress and profits on the use of improved machinery offer rewards that will continue to spur on the ambitious mechanic; and although the present period of prosperity cannot continue without interruption, it is not probable that any one now living will witness the surrender by this country of the lead it has acquired in the design and manufacture of labor-saving appliances.

This is not a special number of MACHINERY, although it contains more advertising than usual. No canvass was made to obtain additional business for the September number, because we wished it to be a fair specimen, both as to reading and advertising, of what the paper will be during the coming year—except that we shall try to improve it each succeeding month. L.

THE ENGINEERING EDITION OF "MACHINERY."

The dollar edition of MACHINERY has attained the largest paid circulation ever reached by a mechanical paper and will be continued at the present price, as the Shop Edition.

There is no monthly in this country devoted to constructive mechanical engineering, although there are several valuable publications which cover the general engineering field with matter of a descriptive and popular character; and the Engineering Edition of MACHINERY has been published in response to a demand for a technical monthly for mechanical and consulting engineers, superintendents and others engaged in actual constructive work, who desire to keep closely in touch with mechanical progress without taking the time necessary to read several publications.

A number of important features will be introduced in the Engineering Edition, beginning this month, of which the following is a brief summary:

FIRST—The articles will be mainly technical, rather than descriptive or popular. They will contain specific information relating to the design, construction and operation of machinery and kindred subjects; and will thus be valuable for future as well as present reference.

SECOND—No write-ups or matter for advertising or other considerations except the merit of the article illustrated have ever been inserted in MACHINERY; but in their place a very complete summary has lately been given, containing short descriptive articles on new tools or machines that have just been placed on the market. Information concerning these is obtained systematically, and although MACHINERY already publishes more descriptions of such machines than all the other papers combined, this department will be further extended.

THIRD—It is intended that the Engineering Edition shall cover its field so thoroughly that even if no other paper is seen the reader will obtain all the important mechanical news of the month, and to this end there will be editorial note and comment on all noteworthy mechanical events in each number. This matter will be systematically gathered and will be so complete that the readers will be kept in close touch with mechanical progress. In many respects this will be the most valuable feature of the paper.

FOURTH—A digest of leading articles in the engineering papers will be given in each number, together with a list of other articles which do not receive extended mention. The digest will be edited with a view to giving the substance of items that are of the most interest to constructive engineers.

FIFTH—A data sheet will be published each month containing tables, diagrams and other information of practical value, in condensed form, most of which will be taken from the proceedings of the various engineering societies. As these proceedings are usually seen only by the members of the societies issuing them, much valuable matter is lost to professional men. The data sheets will represent this material in the most condensed possible form without sacrificing any part that is of value.

SIXTH—The collection and publication of data from the proceedings of engineering societies will be extended so as to include information covering important laboratory work conducted either by the technical colleges or private testing laboratories. The results of many important tests are now not published at all, and it is believed that their preservation in permanent form will be of great value to all who are interested therein.

Subscribers to the dollar edition of MACHINERY may have their names transferred to the subscription list of the Engineering Edition by remitting to this office at the rate of six cents for each month of their unexpired subscriptions; or, if more convenient, the payment may be made to the club organizers.

* * *

A mechanical engineer of Zurich, Switzerland, Mr. L. Thormann, claims that there is enough unutilized water power going to waste at twenty-one waterfalls in the Alps to operate all the railways in Switzerland. In time this power will probably be used to operate these railroads by electricity in place of steam locomotives. This would be an important economical advance, as Switzerland has to import all the coal used within her borders.

LETTERS UPON PRACTICAL SUBJECTS.

AXLES FOR INDUSTRIAL CARS.

Editor MACHINERY:

At the machine company where I am located at present we have occasion to turn quite a large number of axles for industrial cars. These are made from 2-inch square steel about 65 inches long and have their ends turned to 1 15-16 inches diameter for a distance of eight inches. The bodies of the axles are left square. When wanted we usually had to get them out in a hurry and the work required nearly all of our medium size lathes, each lathe averaging about eight axles per day. Fig. 1 shows an old timer of a lathe rebuilt, on which we

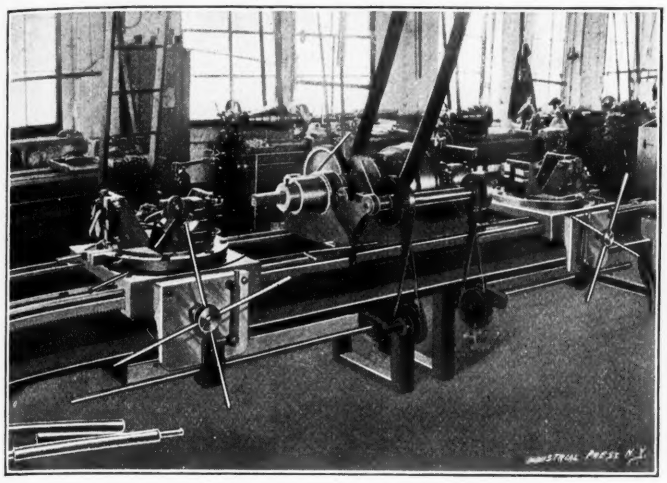


Fig. 1. Old Lathe Rebuilt for Turning Axles.

are turning out forty axles per day. While we do not think the machine is a beauty in design, it is not far behind in its output.

It consists of a strongly made headstock carrying a hollow spindle large enough for the material to pass through freely. On each end of the spindle is a cast-iron chuck with square hole and four setscrews for a slight adjustment of the work. The plate on which the turret tools are fastened has equally spaced holes in which the locking pin locates each tool in its correct position. Around the plate is a clamping ring *B*, Fig. 2, which is tightened by the cam lever *C*, and holds the plate-carrying tools in a rigid manner.

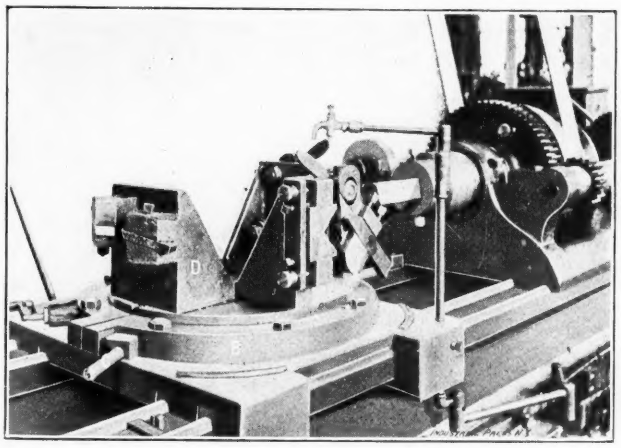


Fig. 2. Turret and Tools Equipment.

For turning axles we have only three operations. The tool *D* is for pointing the end; the other two tools are similar to those on a Jones & Lamson turret lathe—one being used to rough out, the other to finish. The cut shows the construction quite plainly, and also indicates that plenty of cast iron and steel has been used to make it stand the abuse that it gets in coarse feeds, and the shock from turning off corners of square stock.

While not in use as an axle lathe, we use one end of the lathe to do larger work than our Jones & Lamson turret can handle, having a tool holder in which the automatic die for threading from the other turret lathes interchange. We have also fitted a regular four-jawed chuck to one end of the spindle, so that the possibilities of the machine have been multiplied for quite a number of jobs. A. A. AVERY.

Warren, Pa.

THEORY AND PRACTICE.

Editor MACHINERY:

In W.'s article on page 361 he asks for an explanation of the paradox concerning scientific laws and actual practice in the matter of frictional resistance. First permit me to quote the stock phrase, "Theory and practice are never at variance," and then I will attempt to show that it is true in this case.

All surfaces, however smooth or polished they may be, have minute elevations and depressions in them, owing to the porosity, to a greater or less degree, of all matter. Consequently, when two surfaces are in contact the elevations of one drop into the hollow of the other and a resistance called friction is offered to an attempt to move one body over the other in the plane of their contact. This friction consists in the resistance offered by the elevations in the material to breaking off or bending over and in the weight or perpendicularly applied pressure that must be overcome in order that the body may rise sufficiently to allow the elevations to slip up out of one hollow and down into the next, etc. From this it is evident that friction is dependent upon the kind of material, upon the condition of the surfaces as to smoothness, and upon the weight or pressure perpendicularly applied. That is, the harder the substance the more difficult it will be to break off the elevations and fill up the hollows; the rougher the surface the higher will be the elevations and the deeper will be the depressions; the greater the weight or perpendicularly applied pressure the greater must be the force exerted in order to raise the body so that the elevations may pass from depression to depression.

Friction is independent of the area of the surfaces in contact. Provided the weight was the same there would be no more friction or resistance to the motion of a large planer bed upon its ways than there would be to the motion of a small planer bed upon its correspondingly small ways. I hear you say that the larger the ways the greater would be the number of elevations and hollows in the surfaces of the rubbing parts. All of which is true, but the weight is distributed over a larger area and is proportionately less upon each particular roughness of the surface; consequently the friction of each particular particle is less with a surface of large area than with a surface of small area where the pressure upon each particle is greater. The aggregate friction is the same whether you have a large number of small frictions or a small number of large frictions.

When, however, the pressure becomes so great that the material is unable to withstand it and crushes down, a cutting action is produced when an attempt is made to slide the surface of one body over the other in the plane of their contact. Take a flat plate of lead and place upon it a weight, with a flat side in contact with the plate, so heavy that it sinks slightly into the lead plate. Now attempt to slide the weight along on it and a shaving of lead curls up in front of the weight. That is not mere sliding friction resisting the motion of the weight—that is a shearing or cutting action, *i. e.*, an intense friction increasing more rapidly than the pressure. When the surfaces are large enough to stand up under the load without crushing and cutting then the friction is the same, regardless of the area of the surfaces.

It was originally supposed that friction was also independent of velocity, but the later experiments of Bochet show that after a speed of approximately one foot per second is exceeded it decreases gradually as the velocity increases.

It will take more force to overcome the friction of quiescence than it will to keep a body in motion. This is especially noticeable where one body is sufficiently heavy to

slightly indent the other when at rest, but this excess of friction may be instantly overcome by a slight jar.

Thus far I have only followed in the footsteps of X and stated the general laws of friction. Much more might be said on this interesting subject but it does not come within the scope of this article. For the benefit of any who may desire to go farther into this subject or obtain values of the coefficient of friction for different substances, I will refer them to: "Machinery and Millwork, by W. J. M. Rankine," pages 348-354 inclusive; "Theoretical Mechanics, by Julius Weisbach," pages 309-370 inclusive; "Nouv. Recherches expérimentales sur le frottement de glissement, par M. Bochet," in the Annales des Mines, Cinq. Serie, Tome XIX, Paris, 1861.

I will now endeavor to explain why a larger disk would have had more effect than the small one in checking the speed of rotation of the drum, and why the small shaft revolved when the live center was in the deeper hole in the end of the shaft, and remained stationary when the shaft was turned end for end.

The question in dispute between X and Y is, in reality, not one of friction at all; but, instead, one of moments. Place the one-inch disk against the end of the four-inch drum with their centers coincident and the frictional resistance is not applied at the center or axis of the drum, but at a distance from it equal to two-thirds of the radius of the disk. Perhaps if I work a few examples my meaning will be more clear. First, let us assume that the condition of surface, velocity of rubbing and pressure exerted remain constant. We will consider in all four cases: The one-inch disk with its center coincident with the axis of the drum; a four-inch disk having its center coincident with the axis of the drum; the one-inch disk with its center at a given distance from the center of the drum, and a ring with its inner and outer diameters three and four inches respectively and its center coincident with the axis of the drum.

Let P = the pressure applied perpendicularly to the disk—say ten pounds.

Let f = the coefficient of friction, *i. e.*, the ratio of the friction for a given material and condition of surface to a perpendicularly applied pressure of one pound = .5 for dry leather on a metal surface.

Let l = the leverage, or distance from the center of application of the frictional resistance to the center of the rotation.

The mechanical effort = P l f.

Let r = the radius of the disk.

In the first two cases the mechanical effort equals

$$Plf = \frac{2Prf}{3} = \frac{2 \times 10 \times r \times .5}{3} = \frac{10 \times r}{3}$$

As r in the second case is four times the length of r in the first case, the mechanical effort must necessarily be four times as great as in the first case; or, in order to obtain the same effort the pressure exerted would only need to be one-fourth as great. Thus Y was correct in thinking that the use of the larger disk would show a better design, and also in saying that "The disk would last longer." The larger disk would retard the rotation of the drum more than the small one—not because of more friction, but because of the greater effort or moment obtained on account of the greater radius of the larger disk. Moreover, it would last longer because the unit pressure and consequently wear of the larger disk would be less than that of the smaller one.

Now let us see what the result would be if we should move the smaller disk toward the circumference until its center is at a distance from the center of the drum equal to two-thirds of the radius of the larger disk. As the moment arm is the same we would have the same effort exerted and the same pressure required to produce the result obtained by using the large disk with its center coincident with the center of the drum; but, as before, the wear on the small disk would be greater on account of the greater unit pressure.

We will now consider the fourth case, of the ring and the effort exerted by it to retard the motion of the drum. Take the large disk previously spoken of and cut out the center of its face, leaving a ring bearing surface at the outside one-half inch in width.

Let r_1 = the larger radius of the ring.

Let r_2 = the smaller radius of the ring.

Then the center of application or leverage of the frictional resistance will be at

$$\frac{2}{3} \times \frac{r_1^3 - r_2^3}{r_1^2 - r_2^2} = \frac{2}{3} \times \frac{8 - 3.375}{4 - 2.25} = 1.762$$

inches from the center of the drum. As the center of application of the resistance is at a distance from the center of the drum of only .33 inches in the case of the small disk and 1.33 inches in the case of the large one, we find that we only require .187 as much pressure in the one case and .755 as much in the other by the use of the ring as we do if we use the disks and bring the center of application nearer to the center of rotation of the drum. This shows that the greater the leverage the greater will be the effort retarding the rotation. If we continue this idea the leverage of the resistance may be made so great as to entirely overcome the turning effort and we have an effectual brake holding the drum stationary after the clutch that holds it has been thrown out.

It was the same principle of moments involved in the turning or non-turning of the piece of shafting between the centers. Thus theory—when it is known—agrees with practice.

Sc. Pr.

SPACING THE TEETH FOR A RACK PATTERN.

Editor Machinery:

We have had, at various times, to make patterns of a double rack, Fig. 1, on which a gear runs alternately first on one side and then on the other, and which is used for driving the beds of printing presses. In measuring the patterns I have been surprised at their exceeding accuracy, and also at

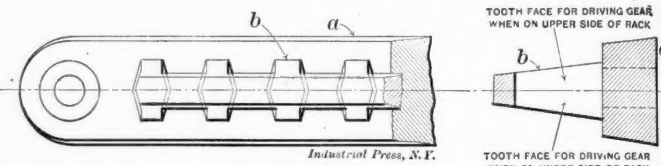


Fig. 1.

the rapidity with which they were made, and it has occurred to me that the method used in making them might be of interest to your readers.

The teeth *b*, Fig. 1, are made separately with a tenon which fits a corresponding mortise in *a*. All of this is simple enough until we get to making the mortises and spacing them accurately.

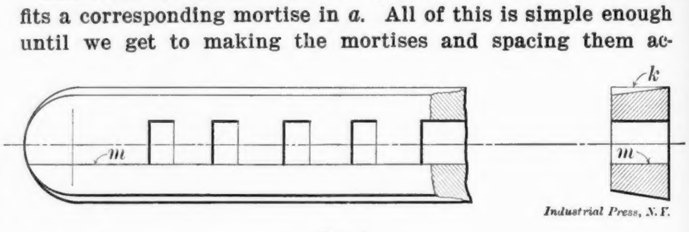


Fig. 2.

The back part *a* is made in two parts divided on the line *m*, Fig. 2. The mortises are cut on a circular saw and the spacing is done as follows: First a hardwood stick *q*, Figs. 3 and 4, about ⅛ inch x ¾ inch, and of sufficient length for the rack, is carefully spaced to the correct pitch,

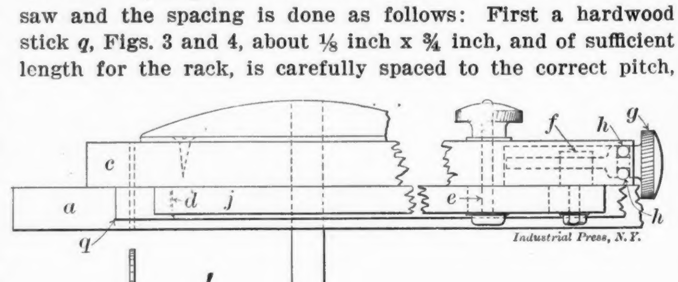


Fig. 3.

the center of each tooth being cut square across with a knife and to a considerable depth. This is temporarily fastened to the top of the back *a*, being left square as indicated at *k*, Fig. 2.

The cross-cut gage of the saw table is screwed firmly to a

piece *c*, Figs. 3 and 4. A piece *j*, shaved down thin enough on the end to spring easily, is held to *c* by means of a bolt *e* in a slot in *j*, and is adjusted crossways of the saw table by means of a nut and thumb screw *f* and *g*, the end motion of the screw being checked by the pin *h*. At the left end of *c* is a thin knife edge, *d*.

To use this device the back *a* is placed against the gage *c*, and the knife edge dropped into the first notch in the spacing stick, when a saw cut is made. Then take hold of the piece *j* and spring it up while the back is moved along until the

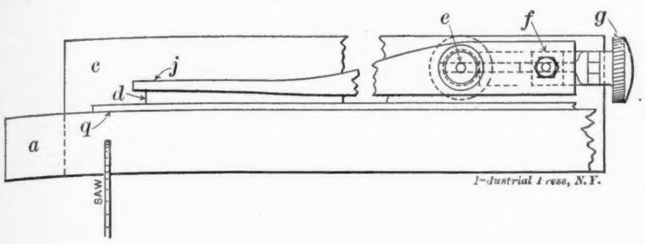


Fig. 4.

knife edge will drop into the next notch, when another saw cut is made. Proceed thus until one side of all the mortises has been sawn. Then go back to the first cut and saw the other side of the mortises in a similar way, first adjusting for the width of mortise by means of the bolt *e* and thumb-screw *g*.

The tenons on the teeth must be a good fit in the mortises and all be alike. In driving them care must be taken to get them straight, which is not a difficult matter if the glue is properly used. The glue should be thin and used sparingly, a little good glue being much better than more, for any kind of work.

New London, Conn. FRED S. ENGLISH.

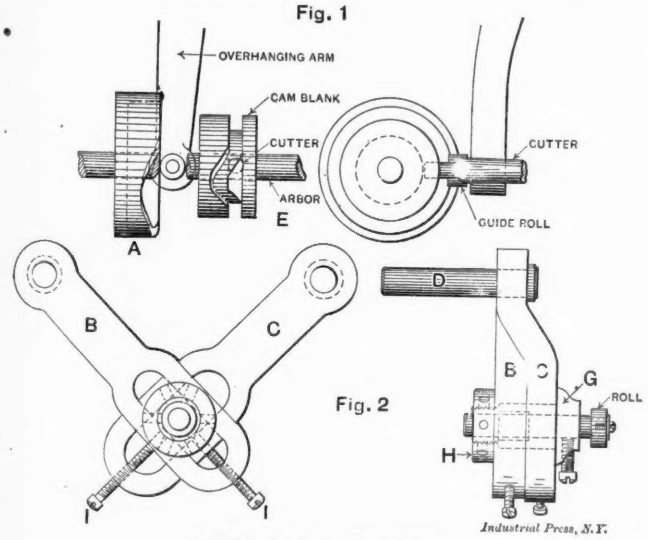
MILLING CAMS.

Editor MACHINERY:

The accompanying sketch and photograph show a very convenient method of milling the grooves in positive motion cams of the type shown at *E* in Fig. 1.

The guide *A* is a cup-shaped casting, the walls of which are about ¼ inch thick. Castings of these guides can be kept on hand and the grinding edge easily finished by hand for any cam required. In preparing the guide it is well to face the outer edge at the back so as to have a true surface from which to work when laying out the throws of the cam. If the cir-

Fig. 1



Details of Cam Milling Fixture.

cumference of the guide is divided into any desired number of divisions and the different distances measured endwise from the true edge, the cam can be easily laid out.

Having shaped the edge of the guide to the desired form, the guide and cam blank are put on an arbor and mounted on the index centers of a universal milling machine. The overhanging arm of the milling machine is fitted with a pin and guide roll and is set slightly to one side of the center of the spindle so as to bring the guide roll in contact with the edge of the guide. This guide roll is made long enough to allow the cutter to be fed into the cam the full depth of the grooves.

In operation the arbor with the form and blank is revolved by turning the index crank. At the same time the guide is held against the guide roll by moving the table of the machine. The cutter is fed, a little at a time, endwise into the cam blank.

I have found that a very convenient machine for doing this work is a vertical mill, or die sinking machine, provided with some means for holding the guide roll. The photograph shows a cam being cut by this method. As will be seen, the cam blank and guide are mounted on the same arbor, which is held on the index centers.

Fig. 2 shows the device which is used to hold the guide roll. It consists of two cast-iron arms, *B* and *C*, one of which, *C*, is offset to allow the end to pass under the end of *B*.

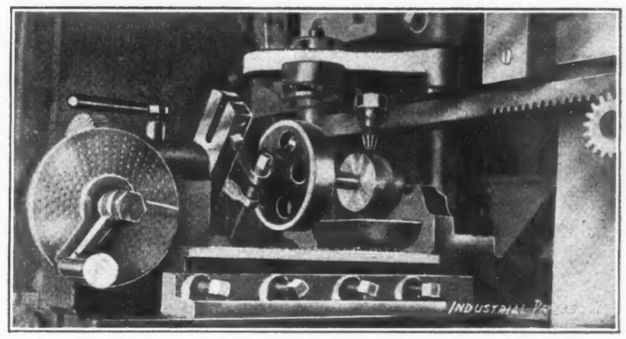


Fig. 3. Fixture Attached to a Milling Machine.

In the end of each arm is driven a pin, the projecting ends of which are fitted to the guide pin holes on each side of the spindle. Setscrews secure these pins when they are put in place. The outer ends of the arms are clamped together by the nut *H* and the bushing *G*, through which runs a pin carrying the guide roll. The setscrews *II* provide for locating and adjusting the guide roll.

I have found a two-lip mill to be the best for roughing out either steel or cast-iron cams, and it is sometimes the best for the finishing cut also.

Meriden, Conn. JAMES P. HAYES.

MORE ABOUT FRICTION.

Editor MACHINERY:

In the August issue "Practice" discusses the reason for the deep center and shallow center and apparently proves his case. When it comes to the theory and practice of friction, however, there are some cases which keep a fellow guessing. Take modern locomotive practice and we find some peculiar features. The driving boxes carry from 18,000 to 25,000 pounds each, or in the neighborhood of 300 pounds per square inch of projected area. These boxes must have a good bearing nearly halfway round or there is trouble from heating.

The truck boxes of the same locomotive seem to be governed by a different law, but of course they are not. These carry perhaps 10,000 pounds each, but instead of having a full bearing on top of the axle there are two babbitt strips running lengthwise. These strips are usually one inch wide and spaced quite a distance apart. Take the projected area of these strips and we find it a pretty small amount, making the pressure per square inch run up pretty high. Yet these bearings run cool until the strips wear down so there is a bearing at the top of axle and box; then they heat. Why?

The tender truck boxes, on the other hand, have the regular full bearing the same as the car truck, and they run without much trouble, carrying heavy loads.

The driving box has to stand the thrust of the cylinder and requires the side bearing, while the top of the box carries the load. The truck or leading wheels have bearings almost all front and back, which takes the rolling thrust, but what carries the hood in the absence (practically) of projected area is something of a mystery.

I certainly do not believe that contact surface means friction in every case or a roller bearing would always have more friction than a ball bearing. As showing the tendency in this

direction I may mention that the leading automobile builders are abandoning ball bearings in the wheels and other parts for long plain bearings.

Who has the right theory?

I. B. Rich.

MECHANICS IN THE COUNTRY.

Editor Machinery:

The firm for which I used to work once sold a second-hand threshing engine, and three or four days after, word came that the feed pump of the engine would not work, and "to send a man out at once to make it work." At this the Old Man said: "That is strange; it worked all right here when we tested the engine. We are very busy and I don't see how we can spare a man, but I will just go out myself and see what is eating those fellows anyhow."

He rode out on the train about 15 miles to a small town where a man and team were to meet him. At the station he found a man but no team. The man told him there would be a team and driver in pretty soon with a load of grain, and that they could ride out with him. After waiting some time the Old Man got nervous. He wanted to get home on the noon train. Finally he asked the man how far it was out to where they were threshing, and was told that it was just two and a half miles from the edge of the town. "Well," said the Old Man, "I can walk it if you can." So they started out. It was pretty warm weather and after walking about an hour the Old Man inquired if they were not almost there. "Do you see that little red schoolhouse on ahead there? Well, that is just half way." The schoolhouse appeared to be a mile or more ahead of them. They got to the place at noon and found most of the men at dinner.

Steam was down. The engineer and another man were putting water in the boiler. They had removed the safety valve, and were pouring the water in out of a bucket, whereupon the Old Man remarked that was a sure way to get the water into a boiler. They gave the Old Man a good "roasting" for letting a rig leave the shop when the feed pump could not be made to work, and wanted to know why he didn't send out a man who knew something about engines and pumps; Tom, the foreman, for instance.

The Old Man got a monkey wrench and started to examine the pump. The first thing he did was to open the suction valve, and under it he found a lump of coal large enough to keep the valve open all the time. He called the attention of the engineer (?) to it, but the engineer knew that was not the trouble. So the Old Man said: "Well, I will get my dinner while you get up steam, and we will see if that lump of coal was not the cause of the trouble."

On the farm were three or four crops of corn, plenty of stock and every indication of a prosperous farmer. That dinner, however, "cooked" the Old Man. They had "side meat" (Breakfast bacon) and fried eggs—fried to a crisp: biscuits as hard as hardtack and yellow with soda; dried apple pie sweetened with sorghum molasses; water-logged potatoes and coffee made from scorched wheat, with no sugar and skimmed milk. Even the women folks were mad about the engine not working and would hardly speak to the Old Man, who is generally a great favorite with the women.

But when the engineer got up steam he found that the feed pump worked all right. The crowd then got into better humor, and "guyed" the engineer a little; and the farmer hitched up his buggy and let his wife take the Old Man to town. He got home at 7.30 P. M. Had spent a whole day to take a piece of coal out of a check valve! What any schoolboy could have done in five minutes.

We once rebuilt an engine for a tile and brick factory. The front head was what is sometimes called a false head—held between the cylinder and frame, and quite a job to get at. Originally it had been ground in. The man who put the engine together in the shop had put in a paper gasket, and after the engine had run a short time complaint came to the shop that the front head was leaking. The Old Man, Josh and I went out to fix it. We went Saturday evening about 8 o'clock so as not to interfere with the work at the tile and brick factory. We had the tools necessary to do the work and some good packing to take the place of the paper, which had evidently blown out. We got the head out at about midnight; then the Old Man took a notion that he would like to have that head ground in again. We had not brought any emery, as we were not expecting to grind in the head. I asked the engineer if he had any emery or broken glass. He said: "No, but I have a piece of emery paper." "Well," said I, "bring it here, and also your fire shovel." "You can't grind in a head with emery paper," said the Old Man;; "let Josh go to the shop and get some emery." But it would have taken three or four hours to have gone to the shop and back, so I rolled up the paper and set fire to it. With the ashes we soon had a nice joint, and we got through in time for church next morning.

W. A. Bright.

Decatur, Ill.

FORMULAS FOR BEVEL GEAR BLANKS.

Editor Machinery:

It is necessary when designing to know the outside diameter of gears; both, in order to be sure of a proper amount of clearance between them and a near-by shaft or wall, and also in order to detail the blanks.

For spur gears, every hand-book gives the following or similar formulas:

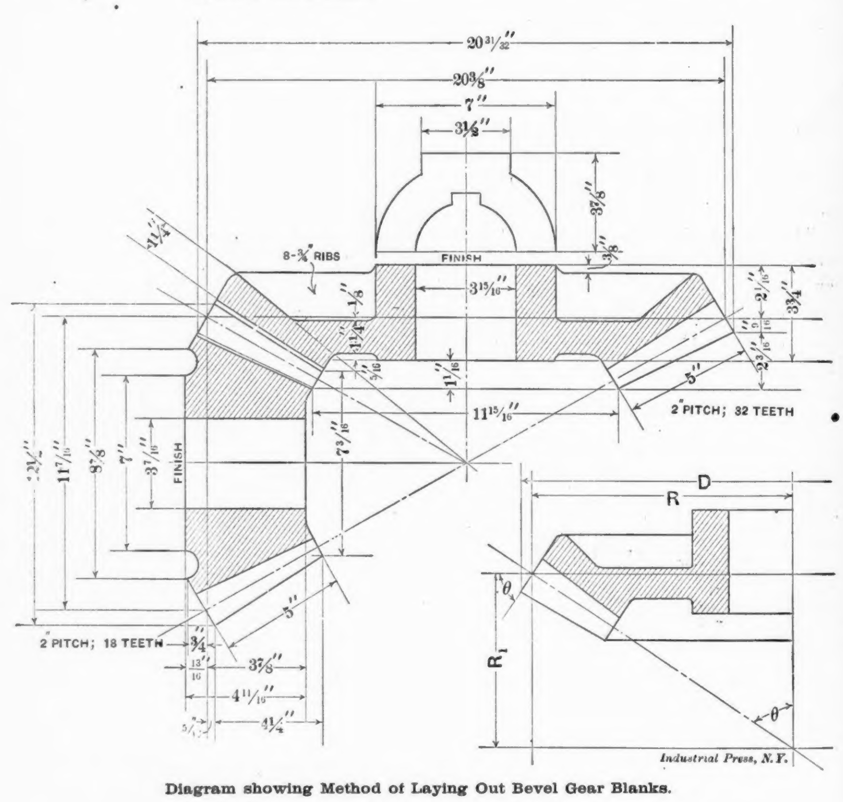


Diagram showing Method of Laying Out Bevel Gear Blanks.

Letting N = Number of teeth
P = Circular pitch
P' = Diametral pitch
d = Pitch diameter
D = Outside diameter.

We have:

$$D = d + .6\,P, \text{ and } D = d + \frac{2}{P'}$$

For a bevel gear, however, the designer, in order to know the outside diameter, must lay out the gear to full size and scale it up, as hand-books do not give any formulas for finding the desired diameter.

This is annoying as it requires the stretching of another

sheet of paper and thus takes quite a little time. As a consequence the following formulas were deduced, to get rid of this difficulty and afford a quick method of arriving at the desired result:

R = One-half pitch diameter of required gear.
R_1 = One-half pitch diameter of meshing gear.
θ = Pitch angle.

Whence

$$D = d + .6\ P \text{ Cosine } \theta.$$

$$D = d + \frac{2 \text{ Cosine } \theta}{P'}$$

Or to avoid trigonometrical expressions:

$$D = d + \frac{.6\ P R_1}{\sqrt{R^2 + R_1^2}}$$

$$D = d + \frac{2\ R_1}{P' \sqrt{R^2 + R_1^2}}$$

The following (see the cut) is an actual case in which the above method was used, and may help to illustrate its use.

Bevel gear:

d = 20.375 inches. R = 10.1875 inches
P = 2 inches R_1 = 5.719 inches

$$D = 20.375 + \frac{.6 \times 2 \times 5.719}{\sqrt{103.8 + 32.7}} = 20.375 + .59 = 20\tfrac{31}{32} \text{ inches}$$

Bevel pinion:

d = 11.4375 inches R = 5.719 inches
P = 2 inches R_1 = 10.1875 inches

$$D = 11.4375 + \frac{.6 \times 2 \times 10\ 1875}{\sqrt{32.7 + 103.8}} = 11.4375 + 1.05 = 12\tfrac{1}{2} \text{ inches.}$$

A. E. H.

THE METRIC SYSTEM IN THE MACHINE SHOP.

Editor MACHINERY:

As the metric system of weights and measures seems to be making considerable progress in this country, it is a good plan for mechanics to become familiar with it so as to keep abreast of the times and so that if Congress should eventually pass a bill making the metric system compulsory after a given time they will be prepared for the change.

The chief objection to the metric system is really an objection to the present system of notation (the Arabic), which has 10 for a base. It is said that if the human race had been created with six fingers on each hand instead of five the base would have been twelve, and if they had neglected to count their thumbs the base would have been 8. Either of these numbers would have been better than 10, as they could easily be sub-divided a greater number of times. When France first used the metric system it was applied to divisions of the circle and time in astronomy and navigation, but this was found unpractical owing to the base being 10. The system was then confined to weights and measures, and has gradually been adopted by the various countries, and seems destined to become universal. The advocates of the metric system have probably been over-zealous in its cause, and, on the other hand, the opponents have said things against it that are not justified by fact.

But on the whole, the adoption of the metric system seems to be desirable, as our units of weight and capacity have no relation to those of measure, and other countries cannot use them in trade with us without considerable inconvenience; and we ourselves are put to a good deal of labor in reducing measures to a common denomination, which in the metric system would be very simple. For machine shop measurements, however, the English system is superior to the metric, because the foot and inch can be readily sub-divided into halves, quarters, etc.

There may be ways to obtain all of the advantages of the English system and still conform to metric units. Had the meter been made 40 inches long instead of about $39\frac{3}{8}$ inches the metric system would probably have been adopted by English speaking people long ago, in order to have a universal standard. It is not likely, however, that the length of the meter can be changed by the countries using it. A meter contains 1,000 millimeters and 1000/40 gives 25 millimeters, which is nearly our present inch. Calling this one-fortieth meter, I would suggest a supplementary table of linear measurements for machine shop use as appended:

25 Millimeters = 1-40 Meter.
4 Fortieth Meters = 1 Decimeter.
10 Decimeters = 1 Meter.

This table would enable us to subdivide the one-fortieth meter the same as we do our inch at present. This would be of great convenience both in the drawing room and machine shop. The scales graduated into millimeters and centimeters are not so convenient for drawing purposes; one is rather too fine, corresponding to 1-32 of an inch; the next higher division, the centimeter, is 10 times as large, and in the machine shop to express fine measurements we use the fraction of the millimeter. For example: To make an allowance for a shrink fit for a shaft about 3 inches in diameter (which is about .006 inch) we would have about 8-50 of a millimeter. If the meter was divided into 40 parts our scales and micrometers could be graduated the same way as at present.

Ordinarily the decimeter need not be used, everything up to one meter being expressed in fortieth meters. This would be a better way of marking dimensions on drawings than feet and inches. Instead of using our two-foot rule the meter measure folded in four parts would make each part nearly 10 inches long, and if it was divided into 40 equal divisions and subdivisions, there would perhaps be fewer mistakes made and time would be saved in using it instead of the two-foot rule. The number 40 can be subdivided into halves, quarters and eighths, so that it is more convenient for subdivision than our dollar of 100 cents.

It is quite likely that the difficulty of changing to the metric system has been magnified. Of course there would be some extra labor in making the change. New measuring instruments would have to be procured, etc., but once the change was made we would get along in the shop the same as before. Much time would be saved in making calculations, estimates, etc., but the greatest benefit would be felt in our foreign trade, as our weights and measures would harmonize with those of the Old World, and England would be likely to soon follow us in adopting the system.

Now, supposing that in five years we were compelled to use the metric system as the only legal standard of weights and measures, what would be the result? This would give time enough so that we would be fully prepared for the change, and there ought to be very little trouble in making it. Probably before that time considerable new machinery would be designed and made to metric measurements. Machines already designed and on the market could be made from the same patterns and with the same tools as before. Standard screw threads and pipe threads would probably not be changed, as there seems to be no metric standard of screw threads used by the different countries, although one was recommended in 1898 by the International Congress for the Standardization of Screw Threads. This system was given in the supplement of MACHINERY for March, 1901. If it was required to cut metric screws the same lathes in use at present could use the same change gears by adding to the set translating gears. One inch = 127-50 of a centimeter; if we use two gears of 127 and 50 teeth for a compound it will enable the cutting of threads in terms of the centimeter instead of the inch. For example: Required to gear a lathe having a lead screw of 6 threads per inch to cut 4 threads per centimeter. 6-4 = 36-24. We could place the 36-T gear on the spindle or stud of lathe; 127-T gear as a follower or first gear on compound stud; the 50-T gear as the second driver, and the 24-T gear on the lead screw. It should be remembered that the 127-T gear should always be a follower, and the 50-T gear a driver. For some cases the compound need not be used, but a 127-T gear is always required to make an English pitch lead screw cut a metric thread, and it should be a follower or driven gear.

But if metric threads were to be the standard, metric pitch lead screws would be furnished with new lathes, and a lead screw of 4 millimeter pitch could replace the common lead screw of 6 threads per inch. Then the common change gears would answer as at present. For example: Required to cut

a thread of 1¾ millimeter pitch, with a 4 millimeter pitch lead screw,

$$\frac{1\frac{3}{4}}{4}=\frac{7}{16}=\frac{28}{64},$$

and 28 on stud and 64 on screw would answer.

The changes to the metric system would, of course, first begin in the drawing room. Probably during the transition period both systems may be necessary for a while, as repairs on machines built on the English system may necessitate this. The change suggested with reference to dividing the meter into 40 parts would enable draftsmen's scales to be graduated the same way as at present. It would not be advisable to call this one-fortieth of a meter an inch, as it might lead to mistakes.

Of course the change to the metric system would necessitate new standard gages, tools, etc. Since the one-fortieth meter is slightly smaller than the inch the reamers, arbors, plug gages, etc., could be ground down to the new standard when it was not desirable to keep them for repairs on old machines.

East Providence, R. I. JOHN T. GIDDINGS.

A BEARING FOR OVEN-CARS AND DRAWERS.

Editor MACHINERY:

Sometimes it is necessary to have a bearing in a place where the varying temperature causes considerable trouble by expansion and contraction, if it is a closed bearing.

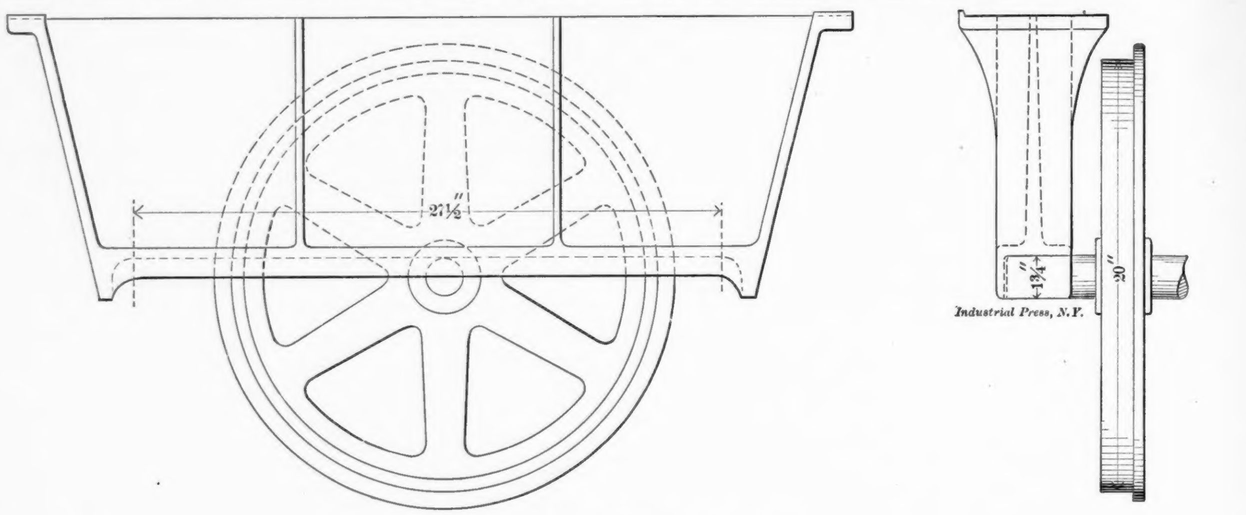


Fig. 1. Compound Wheel and Axle for Oven Cars.

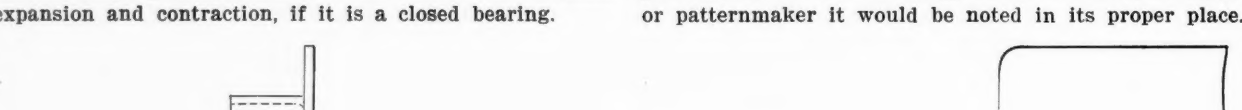


Fig. 2. Another Form of "Rolling Bearing" for use on Drawers.

We are planning a core-oven car and drawer (where the travel required is not great) to have a bearing like Fig. 1, which makes a combination for a car, and one like Fig. 2 for the back end of a drawer. The bearing surface is made long enough to allow for a little more than the distance covered by rolling the axle, which travels with the wheel, being fastened to it. A bearing 27½ inches long for a 1¾-inch axle rolling with a wheel 20 inches in diameter, will carry a car a distance of about 28 feet, and one 9¼ inches long for a 1¼-inch axle rolling with a 12-inch diameter wheel, will carry a drawer a distance of about 8 feet.

This bearing requires no oiling or cleaning. It shields the axle and if any dirt should get on the axle it falls off in revolving. The axle is kept in line by the face of the hub of the wheel for the drawer, and its (axle) end for the car, as can be seen by the sketches.

Taken altogether it makes a very practical bearing for this purpose. Both car and drawer move very easily, cost but little to fit up, do not need attention and are not affected by heat. EDWIN C. THURSTON.

Providence, R. I.

METHODS ADOPTED IN THE MANAGING OF A MACHINE SHOP.

Editor MACHINERY:

Having had charge of a shop where a great many duties were "up to me," I decided to relieve my mind as much as possible from unnecessary worry. With this point in view I took a large book about 8 inches by 14 inches with about 300 pages, and subdivided it as I saw fit. For instance, there were jobs continually coming up which were in no especial hurry, these I would jot down in the note book under the proper heading. If it was a job for machinists it would be put down under this heading; if for the office or blacksmith or patternmaker it would be noted in its proper place. Divisions were made in the book for every class of work throughout the shop. Whenever a man ran out of a job unexpectedly on my part I had but to refer to the book and start him off immediately. I made small cardboard pasters and marked them to correspond with the subdivisions in the book thus: "Machine Shop," "Office," etc., and pasted them where they belonged, with the name projecting about ¾ inch. This

made it possible to turn right to the place desired without loss of time. The note book proved to be worth its "weight in gold." Each time a job was given to a man from the book a lead pencil line through the note showed it was "a dead one."

It was very necessary for me to refer to the material order books quite often. Finding this was very annoying and took a great deal of valuable time, owing to the fact the books used were ordinary duplicate order books, each order having its own number, I instructed the clerk to do as follows: Keep a record of each order on the front inside cover of the book as the orders were made out and when the book was finished transfer names and order numbers to inside back cover of book, but in a classified form, that is, alphabetically. This was a very easy matter when the book was completed. For instance, the order book ran from order No. 450 to No. 525, and the first order in the book was to Blank & Co., then it would be immediately jotted down in the front of the book. Say the next order was See & Bro., followed again by Blank & Co., etc. Then the columns would appear thus:

Blank & Co.,	450—452—456—
See & Bro.,	451—454—
Angel, A.,	453—
Doolittle & Co.,	455—

Then when, as previously stated, the list was classified and transferred to the back of the book, the above would appear in this manner:

Angel, A.,	453—
Blank & Co.,	450—452—456—
Doolittle & Co.,	455—
See & Bro.,	451—454—

From the foregoing it can be readily seen that with very little work it is possible to keep the order books in such shape that any order can be located at once at any "stage of the game." Pasters on the outside of books show the order numbers and dates thus:

Jan 1, '02. Feb. 4, '02.
450 — 525

Chicago, Ill. ROBT. A. LACHMANN.

LACING BELTS.

Editor MACHINERY:

Figs. 1 and 2 show a way of lacing or sewing a belt, which is not new but which has some good features that are often overlooked. I have found that a feed belt for a lathe or drill-press joined in this way lasts longer than any other style I have ever tried.

In making a splice of this kind care should be taken in laying out the holes to space them exactly the same distance apart and this distance should be the amount that will be generally cut off when the belt is taken up; or on a long belt the distance may be made half of this amount, and when the belt needs to be taken up, cut off one or two rows of holes as the

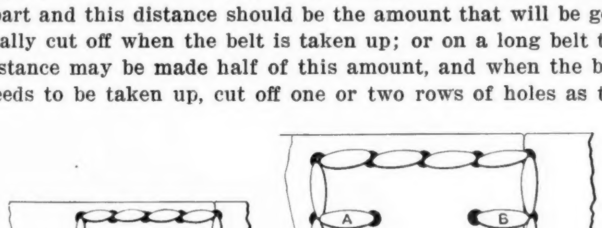


Fig. 1. Fig. 2.

case may be and punch new holes further back to match the other half. This kind of lacing is to be recommended for any place where a belt is kept very tight and gives trouble from tearing out the holes and breaking laces when laced in the ordinary way.

The holes are made much smaller and a very small lace used, and is sewed together the same as a harnessmaker sews a piece of work, i. e., by drawing both ends of lace through the same hole at same time from opposite sides. The larger belt shown in Fig. 2 is done in the same way, except that the loops at *A* and *B* are used to keep the ends of belt down in place and are made with one end of the lace only. When this point is reached it is best, if there is any difference, to use the longest end of lace to make this loop.

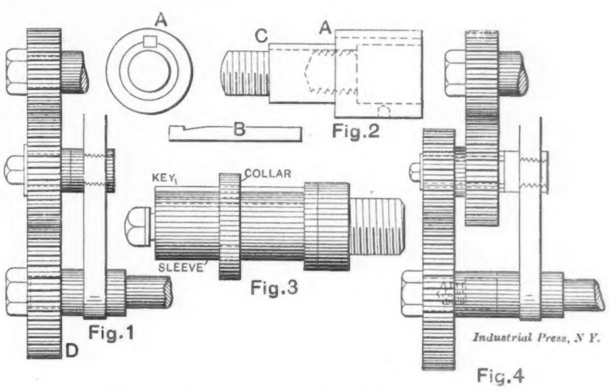
Watervliet, N. Y. M. H. BALL.

A COMPOUND GEARING ARRANGEMENT.

Editor MACHINERY:

Having a lathe which was single geared and desiring to increase its thread-cutting capacity, I arranged it for compound gearing, as shown in the accompanying sketches.

Fig. 1 shows the original gearing on the lathe, with which I could cut from three to 48 threads per inch. I removed the key from the end of the lead screw and in place of the gear *D*,



Method for Compounding a Single-Geared Lathe.

shown in Fig. 1, I screwed on the extension shown in Fig. 2. A keyway was cut in this extension, so that the long key *B* extended from the end of the shoulder at *C* through *A* and into the keyway in the end of the lead screw. It thus locked the extension onto the lead screw and also provided a key for the gear *D*. The notch in the key is to facilitate its removal.

In the place of the original intermediate stud I substituted the stud shown in Fig. 3. On this stud the gears were separated by the collar, while a key, running the entire length of the sleeve, made the gears run together.

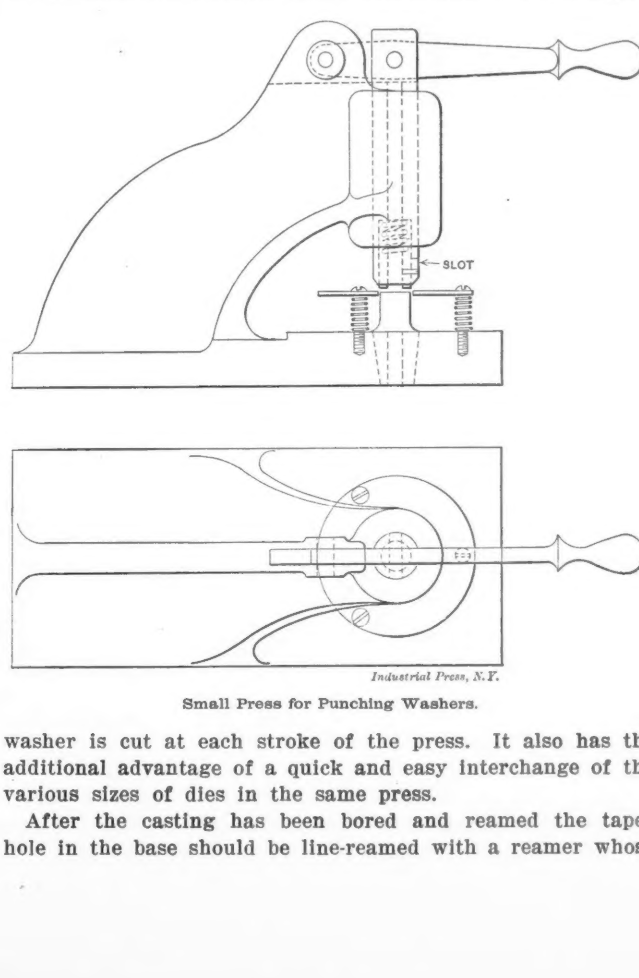
The complete arrangement is shown in Fig. 4. By making this alteration I am now able to cut from 1 to 144 threads per inch.

Meriden, Conn. JAMES P. HAYES.

PUNCH PRESS AND DIE.

Editor MACHINERY:

Accompanying this is a sketch of a small punch press and die for cutting washers from any kind of soft material. By the peculiar construction of the combination die a complete



Small Press for Punching Washers.

washer is cut at each stroke of the press. It also has the additional advantage of a quick and easy interchange of the various sizes of dies in the same press.

After the casting has been bored and reamed the taper hole in the base should be line-reamed with a reamer whose

shank is a snug fit in the long ¾-inch hole. This will insure the absolute alignment of all punches and dies, without the necessity of clamping the die to the press. To obtain the best results both the punch and die should be ground all over; but some may think this an unnecessary refinement. On thick material, however, the hole in the die should be given a little draft to allow the punchings to drop through. It should not be excessive, though, as this will increase the size of the hole at each successive grinding.

I have obtained the best results on mica and fiber by leaving the die almost glass-hard. Because of the numerous small parts such as springs, screws, etc., it might be inferred that there is much repairing connected with the successful operation of the press; but I have found that this may be avoided by a little care in construction. The stock to be used need not be any particular size or shape and on small washers good results have been obtained by using scrap.

New York. H. J. Bachmann.

Fig. 1

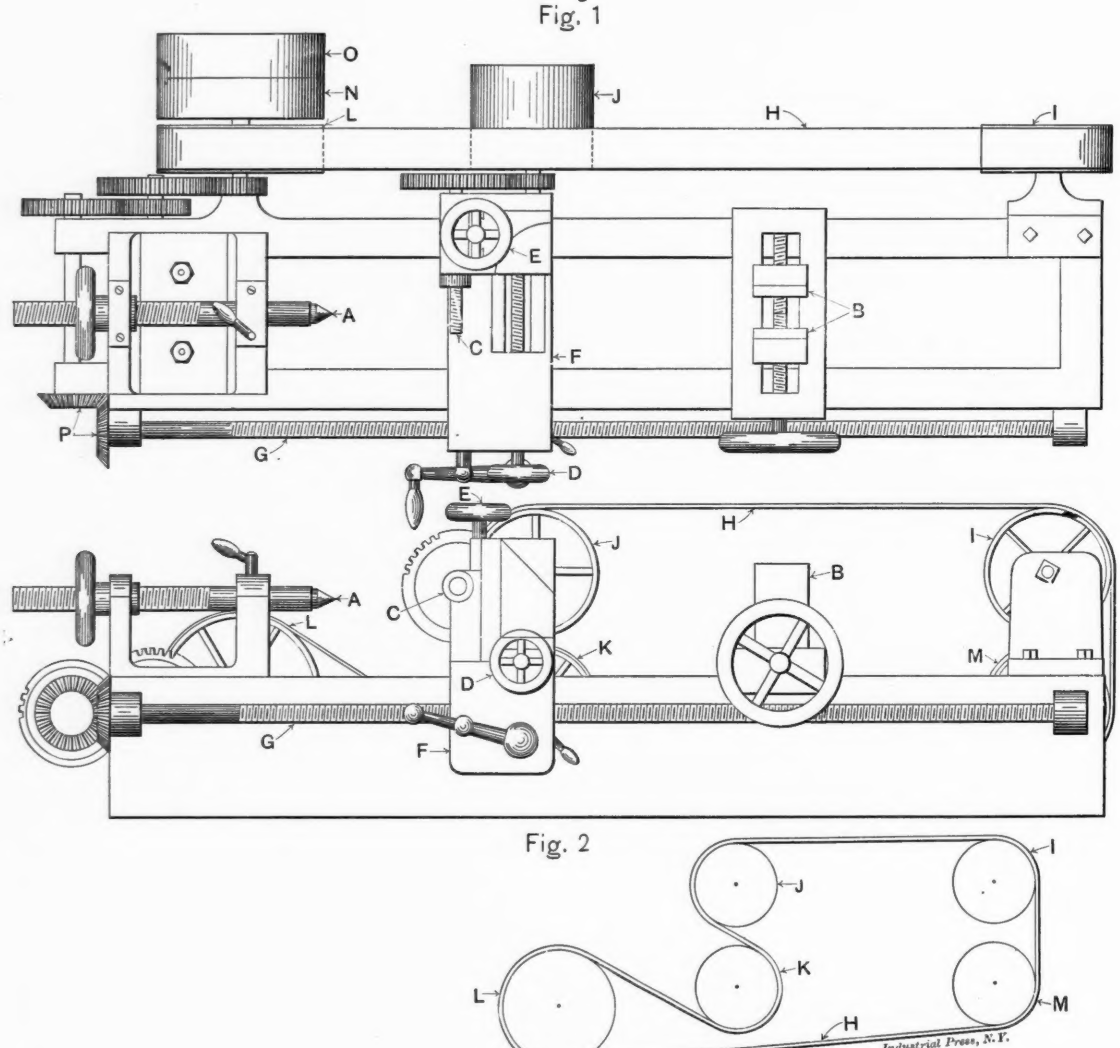


Fig. 3

Splining Machine made from an Old Lathe.

A HOME-MADE SPLINER.

Editor Machinery:

Fig. 1 shows the plan and Fig. 2 the elevation of a very serviceable splining machine which was made from an old lathe.

One end of the shaft to be splined is supported by the center *A*, while the other end is held in the chuck *B*. The keyway is cut by a milling cutter carried on the spindle *C*. Handles *D* and *E* with their feed screws provide for the adjustment of the cutter both centrally and vertically. The carriage *F* carrying the cutting mechanism is fed along the bed longitudinally, by the lead screw *G*, driven by the bevel gears *P*.

The machine is operated by a belt running on the tight and loose pulleys *N* and *O*, while the cutter is driven by the belt *H*. In order to maintain a constant tension in this belt, while the carriage travels from one end of the bed to the other, the pulleys are arranged as shown in the diagram, Fig. 3. As will be seen in the plan, the faces of the pulleys *J* and *K* are made of extra width so as to allow a liberal cross adjustment of the driving mechanism on the carriage.

Connersville, Ind. E. M. Burgess.

HOW A LONG JOB WAS DONE ON AN OLD PLANER.

Editor Machinery:

About ten years ago I had the pleasure (?) of occasionally using an old planer, one of the kind with but one belt and a return motion through gears. During the cutting stroke power was transmitted from the pulley to the table-rack through a train of eleven gears. The best of the bearings were worn not less than 1-16 inch loose and all the teeth (that were left) were worn to a knife edge, so there was quite a period of rest at the end of each stroke to take up the lost motion in the gears and bearings, and the motion of the table that followed was not unlike that of a tin can tied to a dog's tail.

The table was of the thin, flexible kind and had a piece three feet long spliced on at both ends, adding more to the length than to its stiffness, and often when I see a rainbow it reminds me of that planer table at the end of a long stroke.

One day an unusually long piece of work came in. It was so long indeed that I had to remove part of the scrap-heap to give the table room to travel. I got the work bolted on all right, but then my troubles commenced. The table, when near the end of its stroke, hung down badly and was so nearly overbalanced that the rack raised out of mesh with the bull-wheel. I hardly knew what to do; the job was not very particular, but with the table getting one end down and the other

up in the air no job at all could be done. I wanted to get a pulley block over each end of the table and have ropes with weights to counterbalance the ends of the table when traveling in air, but nothing suitable for this arrangement could be found around the shop, so I had to resort to other means.

I found a piece of 1-inch x 3-inch iron and had the blacksmith give it a quarter twist. A stout pin was put through it near the bottom end and two turned cast-iron rollers were mounted on the pin, one on each side of the piece. The piece was bolted to the cross-rail, just alongside of the head. Then by screwing these rollers down tightly against the table by means of the cross-rail screws I succeeded in holding the table down on the ways and the rack in mesh with the bull-wheel until a fairly good job was done.

One good feature about this old planer, or at least one that helped some in this case, was its flexibility. The work was such that I could not keep the chips away from the rollers that held the table down, and when a handful would fall right in front of these I expected a smashup, but it was fun to see that cross-rail accommodate itself to the circumstances and allow the rollers to climb over the chips in fine shape.

There are still many of these old planers scattered through the country, and some of them still capable of producing good work when skillfully handled. But what *can* be done on a machine is not a measure of its usefulness in the shop; good work can also be done and has been done with chisel and file, but the time element is too important a factor to be ignored, and if these old-timers were placed in direct competition with modern heavy, stiff, quick-acting planers it would be an odd kind of a job indeed on which the modern tool would not prove a better investment than those made shortly after Noah's time.

The firm who owned the old planer mentioned above failed, as many firms with such equipments do.

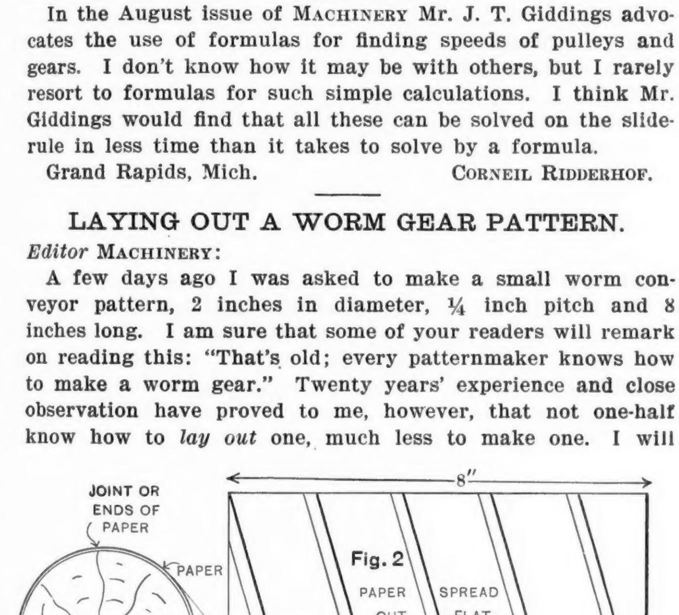
In the August issue of MACHINERY Mr. J. T. Giddings advocates the use of formulas for finding speeds of pulleys and gears. I don't know how it may be with others, but I rarely resort to formulas for such simple calculations. I think Mr. Giddings would find that all these can be solved on the slide-rule in less time than it takes to solve by a formula.

Grand Rapids, Mich. CORNEIL RIDDERHOF.

LAYING OUT A WORM GEAR PATTERN.

Editor MACHINERY:

A few days ago I was asked to make a small worm conveyor pattern, 2 inches in diameter, ¼ inch pitch and 8 inches long. I am sure that some of your readers will remark on reading this: "That's old; every patternmaker knows how to make a worm gear." Twenty years' experience and close observation have proved to me, however, that not one-half know how to *lay out* one, much less to make one. I will



Laying Out Pattern for a Worm.

simply state my method of tracing the lines on the turned pattern. I have traced these lines with a flexible flat spring, also with paper cut to the pitch angle and by other methods in common use, but a better method in my estimation is the following: After turning the pattern to the required diameter, as indicated in Fig. 1, roll a piece of thin paper on the circumference. Now remove and pitch, and draw lines as in Fig. 2, then *glue to the pattern.* This gluing to the pattern is the "kink" that brings success.

"GLUE."

DEVICE FOR CUTTING OIL GROOVES.

Editor MACHINERY:

The accompanying sketches show a device, which I have used for cutting blind oil grooves in bearings, that may be of interest to MACHINERY readers.

Fig. 1 shows the bearing for which this device was designed, but it can easily be adapted to any style of bearing or used for grooving the hubs of loose pulleys.

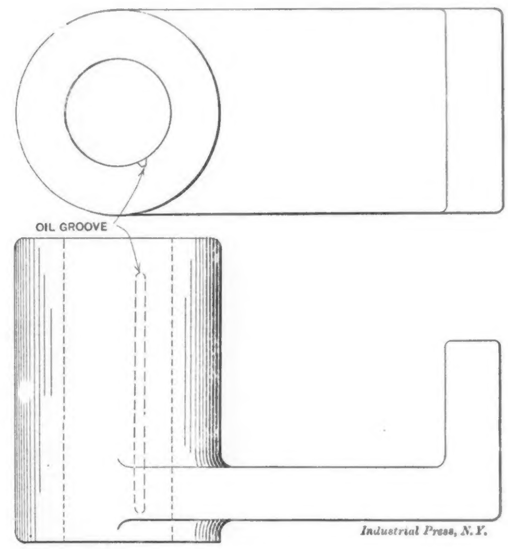
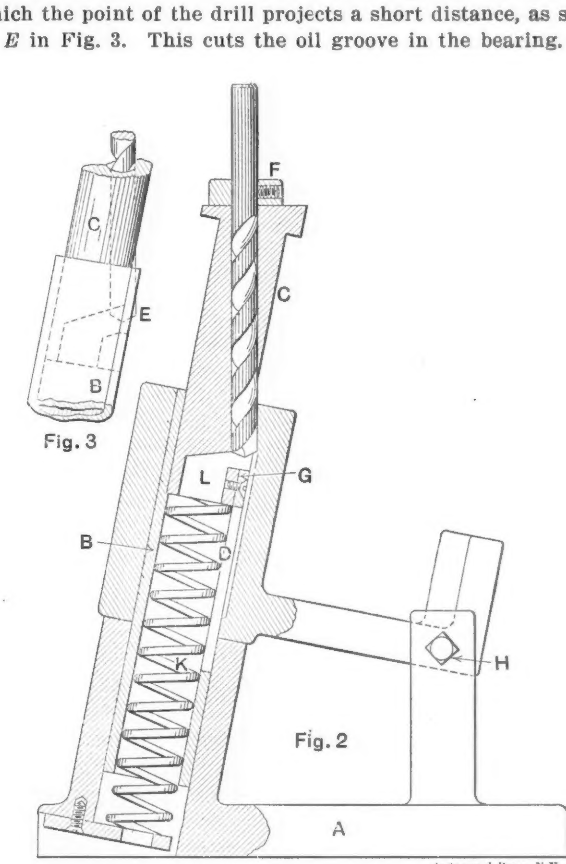


Fig. 1.

The base *A* has an inclined hub in which is forced the hollow bushing *B*, the outside diameter of which is the same as the hole in the bearing. Sliding in this bushing is the plunger *C* through which is drilled a hole perpendicular to the drill table. In one side of the bushing is a slot *D* through which the point of the drill projects a short distance, as shown at *E* in Fig. 3. This cuts the oil groove in the bearing. The



Drill Jig for Cutting Oil Grooves.

amount that the point shall project, and consequently the depth of the oil groove, is regulated by the collar *F* which is held at the desired place on the drill shank by means of a headless setscrew.

The key *G* runs in the slot and prevents the bushing from revolving and also acts as a stop to prevent the plunger from

coming out of the bushing. The shoulder at the top of the plunger serves as a gage for the depth of the oil groove.

To use the device, the bearing is slipped over the bushing as shown in Fig. 2. A lug and setscrew *H* serve as a gage to locate the groove at the proper place in the bearing. The drill is fed down through the plunger as far as the collar *F* will allow and then drill and plunger together are fed down through the bearing until stopped by the shoulder on the plunger. The base *A* is left free to slide along the drill table to provide for the change of position due to the inclination of the plunger.

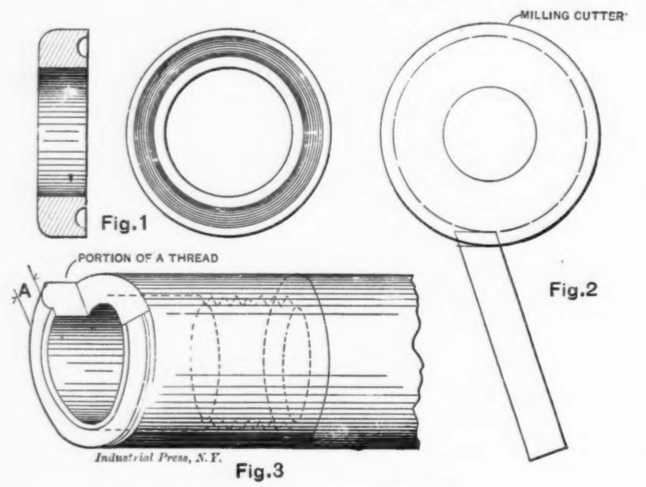
When the drill is withdrawn a spring *K* returns the plunger to its original position. A hole *L*, drilled in the end and side of the plunger, allows for the escape of the chips. As the cut is very light the drill may be run at a high speed and rapid feed. CHARLES THIEL.

Lawrence, Mass.

TOOL FOR TURNING BALL BEARING RINGS.

Editor MACHINERY:

At a shop with which I was connected we were making pieces, as shown in Fig. 1, at the rate of 1,200 per day. They were ball race rings for use in the steering heads of cycles. It was necessary that the groove should finish perfectly smooth, which necessitated continual grinding of the tool. The first tool we tried consisted of a shank containing three loose cutters, with a ring and set pins to hold them in position. This worked very nicely as regards finish, and we used it for a considerable time. The loose cutters were cut at an angle as shown in Fig. 2. When made in this way they could be ground without losing their shape, which of course was absolutely necessary. To find anything to beat this for cheapness appeared somewhat difficult, but we have since made a tool that does beat it, not only in cheapness, but likewise in convenience of grinding and setting. When replacing the loose tools after grinding considerable time was wasted in resetting; it is obvious, that only a slight variation in the diameter of the groove would make a defective bearing, as the rings are used in pairs.



Formed Cutter for Annular Grooves.

The tool shown in Fig. 3 is so simple that it can be ground and reset by the operator, thus dispensing with the aid of a toolmaker. One of these tools has made as many as 6,000 pieces before it was worn out. After hardening, I find it necessary to grind about ⅛ inch off the cutting edge before using, owing to spring in turning tool, which causes the tool to run off at *A*, and so round the cutting edge, causing it to rub; in fact the first one I made would not cut at all through neglecting to do this.

Birmingham, Eng. J. C. HAFNER.

SOME HINTS FOR DRAFTSMEN.

Editor MACHINERY:

Many draftsmen have a habit, and a very good one, of covering the drawing board at night. The majority use a sheet of paper for this purpose; the writer has found that a piece of table oilcloth forms the best covering, as it will not tear; it is heavy, therefore lies flat, and is cheap. In regard to the color to select, white is to be preferred, as dirt can be easily seen on it. To clean, just wipe the glazed side with a damp rag; the rough or unglazed side should be placed next to the drawing. For convenience and to prevent its cracking, tack a stick of wood at one end; it can then be rolled up when not in use.

Frequently a little drop of ink gets down to the edge of the tee-square; the draftsman sees it, and nine times out of ten he pulls his tee-square downward, with the result that he has a very beautiful ink spot ornamenting his drawing. To prevent this it is a good plan to take a slight shaving from the bottom edge of the blade of the tee-square. This can be readily done by scraping the edge with a piece of glass. Triangles may also be treated in this way.

In most cases where it is necessary to erase a small part of a finished drawing it cannot be done without erasing a number of other lines, which, of course, adds to the pleasure of the draftsman, that is, if he is a saint. If, however, the draftsman will take a piece of waste drawing paper and cut out an opening a trifle larger than the portion to be erased and place this over the drawing, then by holding it firmly in place with one hand, he may erase the portion without disturbing any of the other lines. When the part to be erased is circular the opening in the piece of drawing paper is best made by using the low dividers set to the proper radius and turning it around until the paper is cut through.

In regard to the stool used by draftsmen, the writer does not like those with a solid wood seat, as a lake is likely to be formed in the hollow by an innocent chap walking by with a wet sponge accidentally losing some of its water, much to the discomfiture of the owner of the stool when he sits down, and to the amusement of the other occupants of the room.

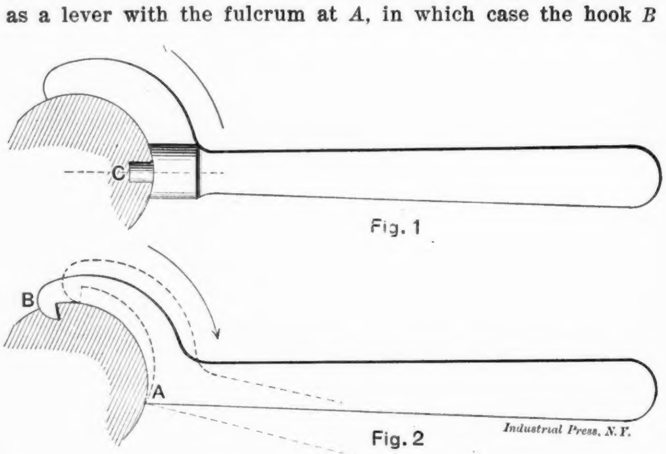
New York. CHARLES G. PEKER.

AN IMPROVED SPANNER.

Editor MACHINERY:

The spanner shown in Fig. 1 may not be new to all your readers, but it is an improvement over the form shown in Fig. 2, which is the kind usually sent out with drill chucks, etc. The trouble with the old kind is its propensity to act as a lever with the fulcrum at *A*, in which case the hook *B* draws out of the notch so that the spanner slips off. In fact, it is not uncommon to see a workman using a bar or some near-by tool to hold the hook into its notch while the chuck is being turned. In the construction shown in Fig. 1 a hole is drilled into the handle into which a pin *C* is driven which will fit loosely into a hole in the chuck. In using this spanner it is necessary to push instead of pulling upon the handle.

W. H. S.



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Tests were conducted last May by the Automobile Club of America to determine the distance in which an automobile can be brought to a full stop by the application of the brake, when running at different speeds. Seventeen automobiles of different types were tested and their speeds were estimated by running them over a course of 1/10 mile. The average results as reported by the technical committee of the club, were as follows: Running at about eight miles an hour, the vehicles stopped at an average distance of nine feet; at a 15-mile speed the stop was accomplished in an average of 29 feet, and at 20 miles the average distance was 53 feet.

HYDRAULIC COMPRESSION OF AIR.*

METHODS OF COMPRESSING AIR BY FALLING WATER—THE EFFICIENCY OF THIS METHOD.

Probably one of the oldest applications of the use of water power to the wants of man was a form of hydraulic air compressor which operated as an entrainment apparatus. This was the well-known water bellows or trompe of the Catalan forges.

This apparatus, briefly described, consisted of a bamboo pole, disposed at a slight inclination from the perpendicular, into the upper end of which a stream of water was led, entraining air with it in its downward passage. The low end of this bamboo pole was introduced into a bag made of the skin of some animal, the air being allowed to escape from the water into the upper part of the bag, whence it was led by pipes or tuyeres to the forge, the water being allowed to escape from the lower edge of the bag. From this original device a great many improvements have been worked out, and besides this a number of other forms of hydraulic air compressors, or of compressors using other liquids for compressing air or other gases, have been designed.

One of the first inventions carrying out this idea was made by J. P. Frizell, Boston, Mass. His invention made use of an inverted syphon having a considerable horizontal run *D* between the two legs *A* and *B*. A stream of water was led into the upper end of the longer leg *A*, and at the top of the horizontal run *D* between the two legs of the syphon was provided an enlarged chamber *C* in which the air separated from

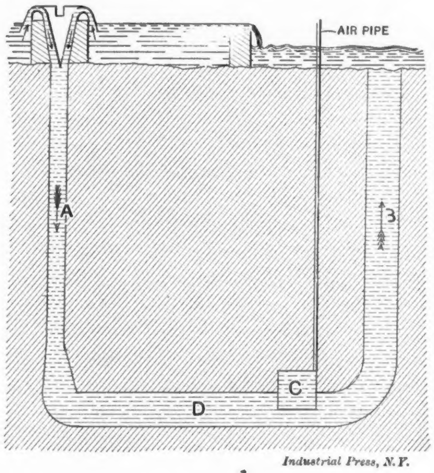


Fig. 1. Frizell System.

the water. The water was then led off from the lower part of this air chamber and passed off through the short leg *B* of the syphon, the pressure of the air accumulated in the air chamber being therefore due to the height of water maintained in the shorter leg of the syphon. This application of carrying upward the water, after the air was separated from it, so as to produce a considerable pressure upon the air, seems to have been original with Mr. Frizell, and in this feature his device differs from the old trompe.

Another device, Fig. 2, differing somewhat from that of Mr. Frizell, was invented by A. Baloche and A. Krahnass in 1885, and consisted of a syphon *B* carrying water from an upper to a lower reservoir, the lower end of the syphon being projected through an inverted vessel *R* placed nearly at the bottom of the second reservoir. Just beyond the bend of the syphon and in line with the axis of its longer leg, an air pipe *T* projected into the descending leg of the syphon. This entrained the air with the descending column and carried it down into the inverted chamber *R*, from which the air escaped at the top, while the water passed out from the bottom into the lower reservoir. This apparatus produced pressure on the air in the top of the inverted chamber, due to the height of the water column upon it.

Another device, Fig. 3, patented by Thomas Arthur in 1888, differs from the last in having a stream of water led directly into the top of the vertical pipe *A*. Inserted into the mouth of this pipe was a double cylindrical cone *C* forming an annular air passage between it and the walls of pipe *A*.

Owing to the increase in the velocity of the water in passing through the narrow throat of the double cone, air is inhaled through the pipe *D*, through the annular space mentioned and through perforations in the lower cone, and is entrained with the falling water.

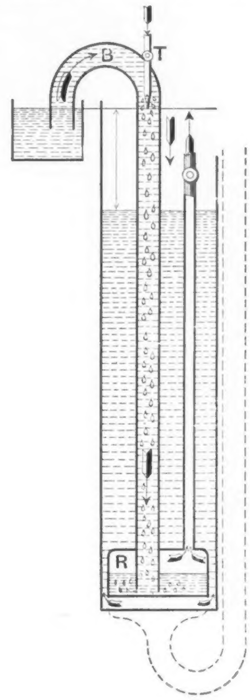


Fig. 2.

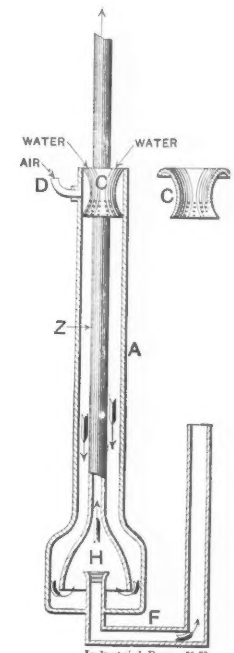


Fig. 3.

Through the downflow pipe *A* rises a vertical delivery pipe *Z* for the compressed air, having its lower end *H* enlarged and open at the bottom. Projecting upward into this enlarged air-delivery pipe was a water escape pipe *F* through which the water passed after having parted with the air. The escape pipe was in the form of an inverted syphon and maintained on the air in the delivery pipe *Z* a pressure due to the elevation of the water at the discharge point above the air line in the large end of the delivery pipe.

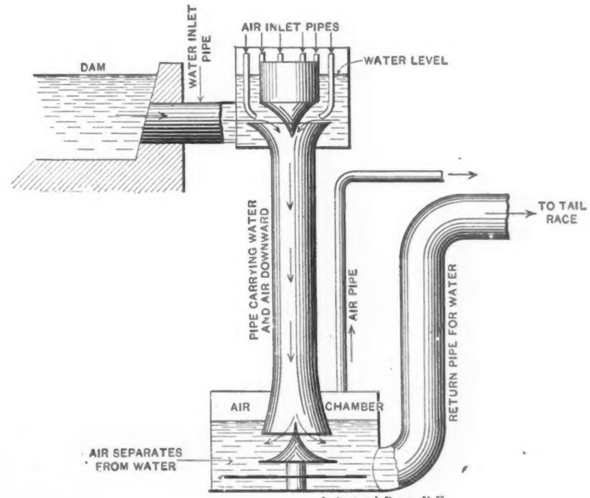


Fig. 4. Taylor System.

A number of other patents on apparatus of this type have been issued to Charles H. Taylor. His invention, Fig. 4, consisted principally of a downflow passage having an enlarged chamber at the bottom and an enlarged tank at the top. A series of small air pipes project into the mouth of the water inlet from the large chamber at the upper end of the vertically descending passage, so as to cause a number of small jets of air to be entrained by the water, Taylor seemingly having been the first to introduce the plan of dividing the air inlets into a multiplicity of smaller apertures evenly distributed over the area of the water inlet.

* From a paper by Wm. O. Webber read before the N. E. Cotton Manufacturers' Association.

The first of these compressors on the Taylor principle was installed at Magog, Quebec, to furnish power for the print works of the Dominion Cotton Mills Company. The head of water is 22 feet; the downflow pipe extends downward through a vertical shaft 10 feet square in cross section and 128 feet deep. At the bottom of the shaft the compressor pipe enters a large tank, which is known as the air chamber and separator.

A series of very careful tests demonstrated that with 19.5 feet head, using 4,292 cubic feet of water per minute, was recovered the equivalent of 1,148 cubic feet of free air per minute, which would represent 248 cubic feet of air per minute compressed to 53.3 pounds pressure, showing that out of a gross water horse power of 158.1, 111.7 horse power of effective work in compressing air was accomplished, giving therefore an efficiency of 71 per cent. In the tests at Magog 81 horse power was recovered, using as a motor an old Corliss engine without any changes in the valve gear; this would represent a total efficiency of work, recovered from the falling water, of 51.2 per cent.

When the compressed air was pre-heated to 267 degrees Fahrenheit, before being used in the engine, 111 horse power was recovered, using 115 pounds of coke per hour, which would equal 23 horse power. The efficiency of work recovered from the falling water and the fuel burned would be, therefore, about 61½ per cent. On the basis of Prof. Riedler's experiments, requiring only 425 cubic feet of air per brake horse power per hour, when pre-heated to 300 degrees Fahrenheit, and used in a hot air jacketed cylinder, the total efficiency secured would have been about 87½ per cent.

In what follows will now be given an estimate of the probable efficiency of different methods of using the power of a water fall. First are tabulated the results that it is reasonable to expect when using turbines and transmitting power by belts and shafting; second by electrical transmission from generators connected to turbines; and finally by an hydraulic air compressor. The compressor, it will be seen, gives the apparently remarkable result of over 100 per cent efficiency. This is due to pre-heating and moistening the air, however, and not to a reversal of mechanical laws.

Given horse power of water.............	1,000	horse	power.
Wheels at 85 per cent efficiency...........	850	"	"
Shafting, pulleys and belts at 80 per cent..	680	"	"

or a total net result of 68 per cent, wheels being at full gate and allowing the minimum loss for friction of shafting.

With wheels as usually run at part gate, the results would be as follows:

Given horse power of water.............	1,000	horse	power.
Wheels at 75 per cent efficiency...........	750	"	"
Shafting, pulleys and belts at 50 per cent (average)	375	"	"

or 37½ per cent of the whole power; both of the above being directly at the site of the water power.

In order to transmit power to a distance, we must take again:

Horse power of water....................	1,000	horse	power.
Wheels at 85 per cent efficiency...........	850	"	"
Generators at 92 per cent efficiency........	780	"	"
Transformers at 92 per cent efficiency......	720	"	"
Line at 95 per cent efficiency..............	680	"	"
Converters at 92 per cent efficiency........	625	"	"
or about 62½ per cent of the whole.			
and direct connected with motors at 90 per cent efficiency	565	"	"
or 56½ per cent of the whole, or if belted at 90 per cent efficiency..............	508	"	"
say 51 per cent of the whole.			

By the use of an hydraulic air compressor:

Horse power of water....................	1,000	horse	power.
Hydraulic compressor at 75 per cent efficiency	750	"	"
Pipe line efficiency at 98 per cent.........	735	"	"
Pre-heating dry air adds 50 per cent. Moistening dry air adds 50 per cent. = 100 per cent	1,470	"	"
Air engines or motors at 78 per cent efficiency or 114.5 per cent.	1,145	"	"
and if belted at 90 per cent efficiency......	1,030	"	"

or 103 per cent of the whole as a resultant effect.

To estimate the efficiency of hydraulic compressing, taking into account the water absorbed by the air and the coal used in heating the air, we have the following:

The weight of a cubic foot of compressed air at 85 pounds and at 70 degrees Fahrenheit, equals .58.

One thousand horse power would represent 750,000 cubic feet of 85-pound air per hour; this would equal 382,000 pounds of air, and as one pound of air will absorb .58 pounds of water, we would require 221,500 pounds of water per hour. The labor represented by forcing 221,500 pounds of water per hour, equal to 3,700 per minute, against 85 pounds pressure, equals 195.5 feet would be $\frac{195.5 \times 3700}{33,000}$ equals about 22 horse power, and as pumps give an efficiency of 50 per cent, equals 44 horse power of work by pump, or 4.4 per cent of the whole 1,000 horse power, this is therefore to be deducted: The coal used in heating the air, which is about one-half pound per horse power per hour, would also represent an amount of work equal to 75 horse power, or 7½ per cent of the whole 1,000 horse power. This added to the 4.4 per cent as above would equal an amount of 13 per cent to be deducted, equals 87 per cent of the whole horse power, or $1,030 \times .87 = .896$, or 89.6 per cent as a final result of all, as against 56½ per cent by electricity, or 68 per cent by water wheels at their best, or 37½ per cent by water wheels at the average.

That our results are within the bounds of reason is shown by the fact that 75 per cent × 98 per cent × 200 per cent × 78 per cent × 87 per cent = 99.5 per cent.

* * *

EVAPORATIVE CONDENSER.

Since the ordinary jet or surface condenser for steam engines requires anywhere from 20 to 40 pounds, or more, condensing water per pound of steam delivered to it from the engine, it follows that a type of condenser that consumes, say, only 6-10 pound of water per pound of steam should possess a considerable economical advantage where water rates are high. The July issue of *Power* contains a description of what is called an evaporative condenser in which a spray of water is drawn through the tubes of a surface condenser, together with a current of air, by a fan exhauster. The success of the device depends on the principle that the evaporation of one pound of water requires as many heat units as will be abstracted from one pound of steam when it is condensed, pressures being equal of course. So if a steam coil containing steam at atmospheric pressure (temperature 212 degrees F.) was sprayed with water, each pound of water evaporated on the exterior should in theory condense one pound of steam on the interior of the coil. In this device a portion of the heat is absorbed by the current of air and the unevaporated water. A test was made in Chicago of this condenser connected to a simple automatic engine 12½ by 20 inches running at 156 turns per minute for a period of 16 hours; steam pressure 90 pounds. The pounds of steam condensed was 24,010; total consumption of spray water, 48,000 pounds; less spray water returned, 33,600 pounds; actual amount of spray water consumed, 14,390 pounds.

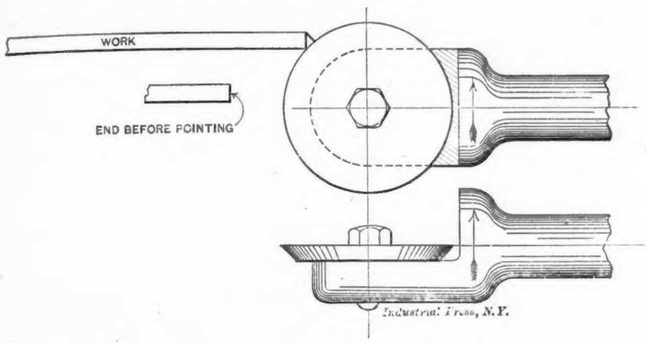
* * *

The proper ratio of the diameter of a wire cable to the pulley sheaves over which it runs should be carefully observed if the maximum life of the cable is desired. Experience has shown that it should not be much less than one to forty where the cable is in constant use, as in elevators. This means that if the cable is one inch in diameter the sheaves should be forty inches in diameter or more. It makes no difference whether the cable makes a turn of 180 degrees or less, the stress on the cable is just the same so long as it is constrained to the curvature of the sheave for even a short arc of its circumference. To illustrate the effect of sheave diameter on cable life the experience of a writer in a contemporary may be mentioned. He found a plant in which two five-eighth-inch cables passed over an 18-inch sheave carrying a 700-pound counterweight. The factor of safety was thirty to one, yet the life of the cables was only two years. One-half inch cables were substituted, which reduced the factor of safety to twenty-five, but doubled the life of the cables.

CONTRIBUTED NOTES AND SHOP KINKS.

POINTING TOOL HAVING CIRCULAR CUTTER.

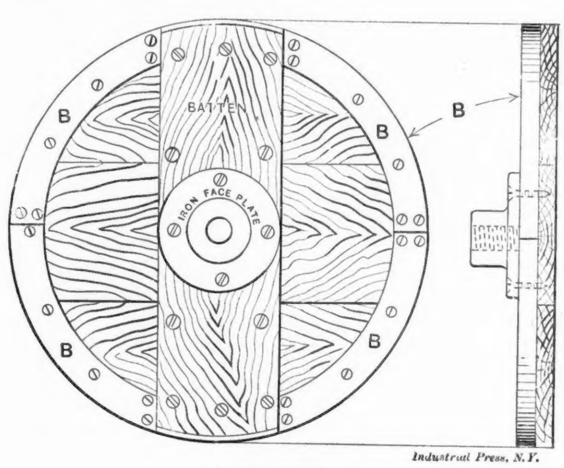
E. M. Lehman, Chicago, Ill., designed and used the pointing tool here shown, some ten years ago. The cutter is about two inches in diameter, which therefore gives about six inches of cutting edge that can be used and made dull before it is necessary to sharpen it. When one section of the cutting



edge becomes dull, the cap screw is loosened and the cutter shifted around about 3-16 inch, thus bringing a sharp section into contact with the work, and so on around until the whole circumference is made dull.

PATTERNMAKERS' LATHE FACEPLATE.

Patternmaker writes: In pattern shops when making face plates it is common practice to take two or three boards 1¼ inch or 1½ inch thick, as the size may require, and screw the batten on back, as shown in the sketch. I go just a little

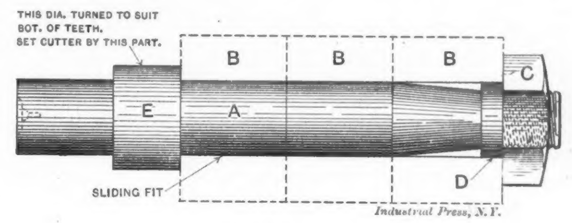


Lathe Faceplate.

farther and screw on segments of the same thickness as the batten shown at *B*. In this way you more than pay the cost when putting hand screws on work. It is annoying to find your hand screw must be put on just at the edge of batten, but with segments the back is even all round.

COMBINATION ARBOR.

Robert A. Lachman, Chicago, Ill., had occasion to cut several steel pinions 4 P. and 17 T. Some of the pinions had straight holes and others taper holes. Most of the machines for which the pinions were made required two with straight holes and one with a taper hole, all being of the same diameter. Some of the machines, however, required all three pinions to have straight holes. It was desirable that the three pinions required for each machine be cut at the same setting so an arbor was made that would carry two straight-hole pinions and one taper hole, or three pinions having straight holes. The pinions were bored and faced on one side while in the chuck and the other side was faced while mounted on an arbor so that the combination arbor shown here was used only for turning the external diameter in the lathe and cutting the teeth in the gear cutter. The cut shows how a straight-hole pinion was mounted on the part of the mandrel intended for pinions having taper holes. A ring *D* was made ¾ inch thick and bored to fit the straight part of the mandrel which had been turned back of the thread. The external diameter of the ring was made the same as that of the mandrel. In this manner the end pinion was supported at both ends in a satisfactory manner. The short distance cut away from the taper bearing did no harm, as there was ample bearing left for supporting



Combination Arbor.

the taper hole pinions. The collar *E* was turned to the same diameter externally as the bottoms of the teeth spaces so that it could be used for setting the cutter before mounting the pinion blanks on it. This obviated all chance of error in depth of tooth space when making the setting.

* * *

HOW AND WHY.

A DEPARTMENT INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST.

Give all details and name and address. The latter are for our own convenience and will not be published

1. Connecticut. What is the best method of reboring the boxes of engine lathes; can they be bored on the ways better than some other way? The lower half of back boxes have a screw in them to take up the end motion of spindle. 2. What is the usual allowance for making shrinking fits, as in shrinking on collars, etc.? Is it advisable under any circumstances to cool with water? 3. Small lathes are often made so that the back bearing is formed by the end of spindle running in a steel bushing (tapered usually); which should be hardened, the end of spindle, or the bushing, or both?

A. We judge from the first inquiry that you have several lathes, the main bearings of which have become worn and are to be rebored. We prefer to mount the headstock on ways and then bore with a rotating bar arranged to feed through the work, as in the case of the bar of a horizontal boring machine. If the boring is to be done on a lathe, however, such an arrangement is not easy to rig up. You might find it feasible to bore the bearings with the headstock in place. We would like to have readers submit suggestions for doing the work. 2. Allow .002 inch per inch diameter. Yes, cool with water; otherwise the center will become hot and will not cool until after the outside parts have cooled. When the center finally cools it will then contract and the fit may be destroyed. 3. When both the spindle and its seat are of steel, both should be hardened.

2. Subscriber. Please explain a method for finding gears to cut worms in a lathe to mesh with worm gears of diametrical pitch. 2. How can I find the angle of the teeth of worm gears other than by laying it out on paper? I want a method that can be used in a shop where there is no drawing to go by.

A. To start with the simplest case, suppose it is desired to cut a worm to mesh with a worm wheel of one diametrical pitch, and that the lathe has a lead screw with one thread per inch, or a screw of one inch pitch. The circular pitch of one diametrical pitch gear is 3.1416 inches, and a very close approximation to this decimal is the fraction 22—7. The worm, therefore, must have a pitch of 3.1416 inches, or 22—7 inches. This fraction, 22—7 should be memorized, as it is the only number that one need have at hand in making change gear calculations for worm threads. In the lathe mentioned the lead screw would advance the tool one inch for every revolution of the screw and would thus have to turn 3.1416 times to advance the tool 3.1416 inches. In other words, the lead screw should turn 3.1416 times as fast as the worm which is being cut. As the fraction 22—7 is equivalent to 3.1416, this result would be accomplished with a 22-tooth gear on the stud and a 7-tooth pinion on the lead screw, or

gears in this ratio, say, 44 on stud and 14 on screw. Now suppose that instead of a lead screw of one thread per inch there was one with three threads per inch. The screw would then have to turn three times as fast as before, to accomplish which the gear on the stud should be three times as large, or else the gear on the screw three times as small as before. The gearing should be in the ratio, therefore, of 3 × 22—7, or 66—7. If the lead screw had four threads per inch the gearing should be in the ratio of 88—7, and if six threads, in the ratio of 132—7. Assume, finally, that it is desired to cut a worm of some pitch other than one, say, to mesh with a worm wheel of four diametrical pitch. The threads of the worm would then be four times as near together as before and the lead screw should turn only one-fourth as fast. The gear on the lead screw could thus be four times as large as in the first example, or the gear on the stud four times as small. With a three-pitch lead screw the gearing should be in the ratio of 66—28; with the four-pitch screw, 88—28, and with the six-pitch screw, 132—28. If a worm for a six-pitch worm wheel were desired, then for the three cases the gearing would be in the ratio of 66—42, 88—42 and 132—42, respectively. Of course it is understood that these fractions may be reduced to their lower terms, in order to reduce the size of the gears. Thus, for a three-pitch lead screw and four-pitch worm we found the ratio 66—28, but it would be more natural to select gears 33 and 14 instead, which bear the same ratio as the others. The foregoing calculations apply only to lathes in which the spindle and lead screw make the same number of turns with equal gears. Where the spindle turns faster or slower than the lead screw, with equal change gears, allowance must be made for this. With compound-geared lathes the simplest plan is to use equal intermediate gears and to put gears on the stud and screw, as calculated above. 2.—The simplest plan is to lay out the angle, even in the shop, as it is very easily done with a scale and try square. In making the calculation, reference must be had to a table of natural tangents. Divide the circular pitch of the worm wheel by the pitch circumference of the worm. The quotient will be the tangent of the angle made by the tooth with the axis of the gear. Where a worm gear is hobbed it is not necessary to have this angle; but if a spur gear with inclined teeth is used for the worm gear, it of course is necessary.

* * *

NUTS FOR CLAMPING BOLTS—PLANER JIG.

The nuts shown in Fig. 1 are samples of clamping bolt nuts used in the shops of the Cincinnati Planer Co. for planers and boring mills. This style of nut replaces the old-fashioned T-head bolt and is said to have many advantages over it. It may be moved along the slots to any point desired and used in connection with a common machine bolt or cap screw. It does not break away the edges of table slots and clamping bolts used with these nuts may be loosened up

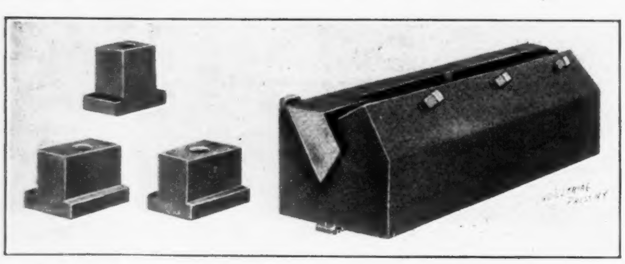


Fig. 1. Fig. 2.

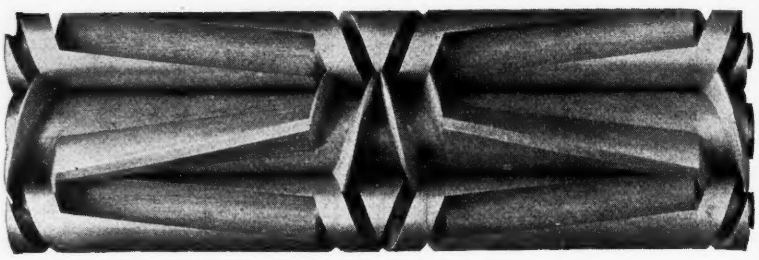
without the work jumping out of place, as has been the experience of many of us with the common T-head bolts. It also gives a more secure hold, as it has a longer and more rigid bearing in the table slot.

Another good scheme used in the same shops, is a simple and efficient jig for planing the edges of dovetailed strips to 30 degrees angle without swiveling the planer heads. The pieces are first planed top and bottom to the required thickness and then the edges are planed in this jig. The slot in the jig is planed out to the required angle so that the upper edge of the piece to be planed is parallel to the planer table. Fig. 2 shows a short piece in a jig ready for planing. Three set screws are provided for clamping it and a lug acts as a stop to take the pressure of the cut off the screws. There is a height gage to which the planer tool is set for finishing. All work planed in this jig is sure to be exactly of the same angle and size.

* * *

HIGH-SPEED HELICAL GEARS.

The Boston Gear Works, Boston, Mass., are devoting a great deal of attention to the construction of gear wheels to run at extremely high speeds. All of their gears for high-speed work are of metal instead of rawhide or fiber so extensively used for this purpose. While metal gears have obvious advantages over those of softer material, they must be made with great accuracy to run smoothly at high speed; otherwise



A Set of Three Helical Gears to Run at 5000 Revolutions a Minute.

the impact of the teeth makes the gears noisy. The Boston Gear Works advocate some form of helical gear and they are prepared to manufacture either spiral gears or gears of the herring-bone type which will run quietly at extremely high speeds. These gears, however, must be cut with great care and their experience is that the index arrangement supplied with standard milling machines is not accurate enough for the purpose. A first-class spur gear cut by a modern gear-cutting machine with its large dividing wheel will run with less noise than an ordinary spiral or herring-bone gear, cut on the milling machine, and spaced with its small index plate.

The style of herring-bone gear recommended is one with the teeth making a much less angle (usually about 10 degrees) with a line parallel with the axis of the gear than in the old style herring bone gear having teeth usually at about 45 degrees with this line. The accompanying illustration shows three special helical gears designed for speeds of 3,000 to 5,000 revolutions per minute. These gears are for special work, of the nature of which we are not informed, except that it was necessary to have three shafts running very near together. The gears have only two teeth each and the angle made by the spiral with the axis of the gear is very small. Gears with two teeth will not run together, however, unless the faces of the gears are long enough for the spiral teeth to make about half a revolution from end to end of the gear and thus engage in the opposite tooth before the first pair of teeth are out of mesh. In this case the angle of the spiral is so small that the faces of the gears would have been excessively long under this condition. The difficulty was overcome by having the angle of the spirals change abruptly at the ends of the teeth so that there is always some portion of each tooth that is driving, no matter what position the gears are in. The difficulty in matching the ends of the teeth where the angles at the center converge and those at the ends diverge, as in this case, can well be appreciated, especially where the gears must run at such high rotative speeds.

* * *

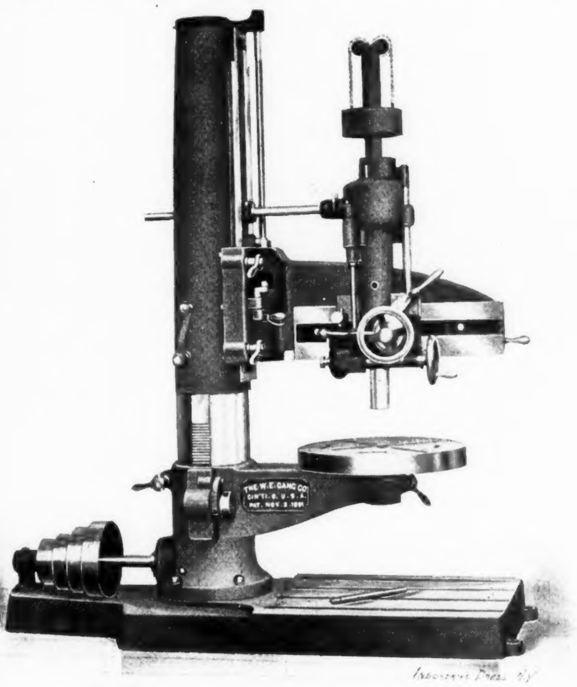
For the purpose of getting the approximate volume of a sphere, it is usually near enough, for the purpose of a rough estimate, to say that it is equal to one-half that of a cube having edges of the same length as the diameter of the sphere. Thus to get the cubic contents of a sphere 3 feet in diameter, multiply the diameter by itself two times and the result by ½; the final product, 13½ cubic feet, is the approximate volume. Thus, $3 \times 3 \times 3 \times \frac{1}{2} = 13\frac{1}{2}$ cubic feet. The actual volume is $3 \times 3 \times 3 \times .5236 = 14.1372$ cubic feet.

NEW TOOLS OF THE MONTH.

A RECORD OF NEW TOOLS AND APPLIANCES FOR MACHINE SHOP USE.

IMPROVED RADIAL DRILL.

We illustrate herewith an improved radial drill built by the Wm. E. Gang Co., of Cincinnati. This is a machine unique in some of its features and well adapted to the requirements of an every-day shop tool. The frame parts are well proportioned, and as evidence of their stiffness it may be mentioned that the seat of the round table is faced off with an inserted tooth mill 9 inches in diameter, fed to its cut by means of the regular gear traversing mechanism, consisting of rack, pinion and hand wheel.



Radial Drill made by the Wm. E. Gang Co.

The lower end of the column is turned to fit in the stump, allowing the arm to swing through a complete circle on its ball bearing. The upper end of the column has a flat seat for the arm, is planed with dovetail flanges at the edges of the arm seat, and back of these again are flat seats for the clamps, which hold the arm in position and also take up any wear incident to raising and lowering the arm. Two screws with handles attached, working in nuts beveled to fit the edges of the arm seat, both clamp the arm and align it vertically. Any tendency to spring the column in clamping the arm is overcome by fitting a square gib in the opening provided for vertical movements of the horizontal driving shaft.

The arm is of box section, well ribbed, and is raised and lowered by means of a stationary screw, a revolving nut and tumbler gears, the movement being controlled by the small lever shown directly between the clamping screws. The head is provided with an ample number of feeds by hand or power, a quick return movement for spindle, and is traversed along the arm by means of rack, pinion and the handwheel at the front.

To concentrate all heavy stress of driving at the spindle three large gears—for ordinary drilling, for heavy boring and tapping, and for reverse in tapping—are placed directly on the spindle. The back gears are just behind them. The upper part of the head is made to entirely surround these driving gears, thus eliminating all attached bearings, affording an excellent protection to the working parts and insuring the workman against injury. A lever at the right of the head enables the operator to quickly start, reverse, connect or disconnect the back gears.

A friction feed is provided and any desired change is obtained instantly by turning the knurled knob at the left of the head.

Any one of four styles of table—a round table, a plain square table, a plain swiveling table, or a worm swiveling table—can be furnished with this machine.

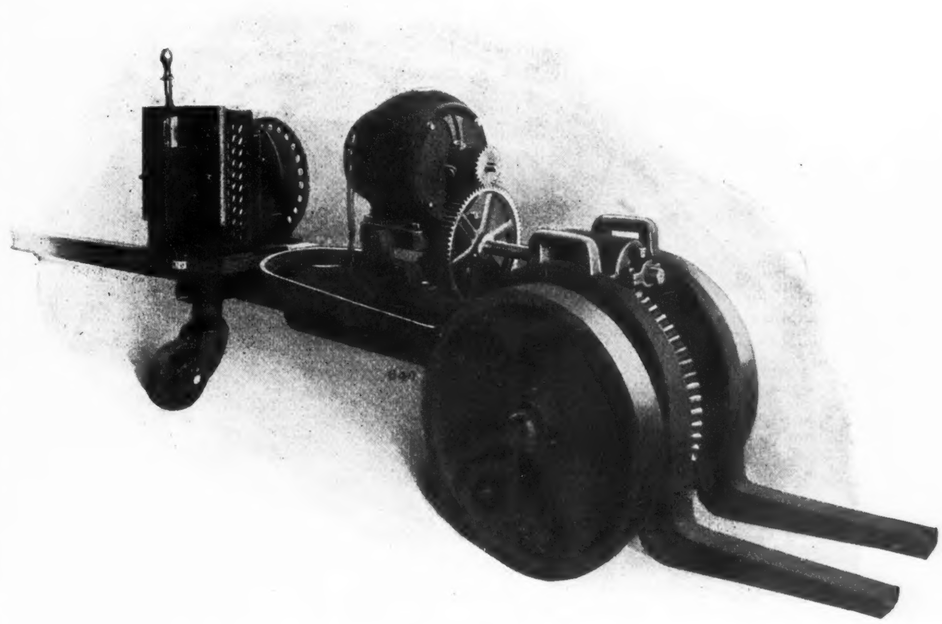
The base is so designed as to give ample strength and stiffness, to provide ample working surface and to occupy no unnecessary floor space.

The machine is provided with eight rates of spindle speed. Others may be added to cover special cases.

NOVEL FOUNDRY TRUCK.

The Northern Electrical Mfg. Co., Madison, Wis., have brought out an electrically-driven foundry truck, shown in the accompanying illustration. The first one of these was built for use in a malleable iron foundry. The old method of placing pots containing the castings in the ovens and taking them out again was an expensive and troublesome operation, requiring from six to twelve men. To remedy this, they equipped the truck here illustrated.

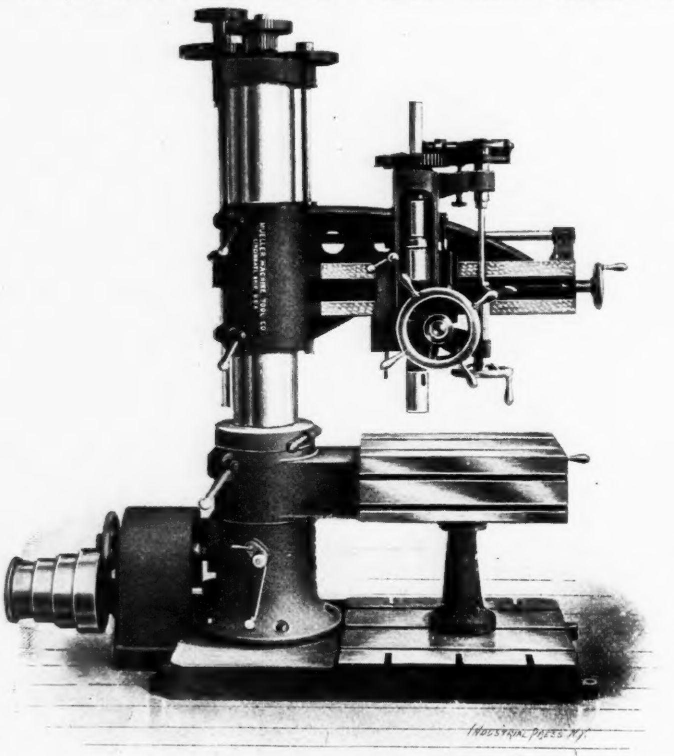
This consists of a "Northern" back-geared motor connected to the truck shaft by means of a worm and gear. On this shaft are mounted the two truck wheels that are keyed fast to the shaft. The forks on the truck are mounted on an eccentric, the eccentric being operated by a lever that is shown between the motor and the controlling apparatus. By raising this lever the forks are dropped down low enough to be shoved in underneath the pot of castings, and by pulling the lever down to the position shown in the cut, the pot of metal is raised. On the front end of the truck is mounted a reel that contains the wire that is paid out automatically as the truck is operated back and forth in the oven. On one side of the reel is mounted a reversible controller that operates the motor. This equipment is so compact and complete that one man can do the work of twelve in a great deal less time than by the old method.



Electrically-driven Foundry Truck.

A NEW TWO AND A HALF FOOT RADIAL DRILL

The illustrations here shown are of a new type radial drill, brought out by the Mueller Machine Tool Co., Cincinnati, Ohio. This machine has a pipe-shaped column clamped directly to a heavy well-ribbed base, thereby insuring the utmost rigidity for the arm and work spindle. The arm is supported by a top cap, resting on steel balls and both revolve easily around the column. By shifting the lower crank to right or left, and by the use of a cone pulley, twelve changes of spindle speed are instantly obtained without stopping the

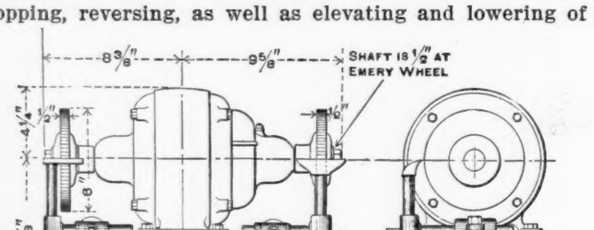


Radial made by Mueller Machine Tool Co.

countershaft. These twelve speeds are equally divided between the maximum and minimum revolutions of the spindle.

The lower driving shaft is the only one in motion when the spindle is not used, a feature that prolongs the life of the machine.

A depth gage reading from zero is on the head, which enables the operator to stop the spindle at any point, or it can be set to automatically throw out the feed at a certain depth. A safety stop prevents automatic feeding beyond the limit of the spindle's stroke. A single lever in front of the column operates a pair of friction clutches, and controls all starting, stopping, reversing, as well as elevating and lowering of the



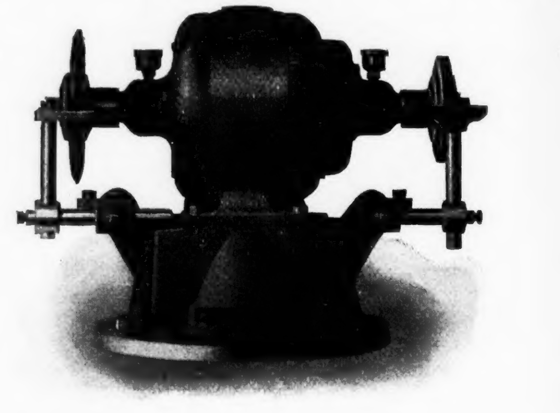
View showing Dimensions of Bench Grinder.

arm at an increased speed. Any amount of feed per revolution of spindle between .007 and .021 can be instantly obtained by a small friction wheel on the head. All tightener handles are fitted on cone-shaped screws, and by loosening the nut in front they can be set to clamp at any point in case of wear. The usual quick return to spindle and tapping device are also provided for.

The net weight of machine is 3,000 pounds. It was designed by Mr. Oscar W. Mueller, formerly of the firm Dreses, Mueller & Co.

"LITTLE BADGER" GRINDER.

The "Little Badger" grinder shown herewith is a bench grinding machine that has been placed on the market by the Northern Electrical Mfg. Co., Madison, Wis. The dimensions are shown in the line cut, and it will be noted that it is so small that it can be easily set wherever convenient on the bench. The base is heavy enough to keep it from tipping

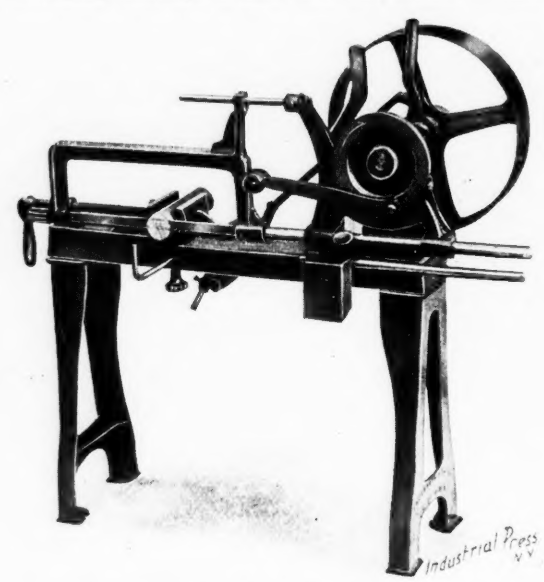


Electrically-driven Bench Grinder.

even if not bolted down, while the machine is light enough to be readily portable. The motor is entirely enclosed and is dust-proof. Tool rests are arranged for grinding either on the face or side of the wheel. The bearings are provided with suitable lubricating devices; there is a take-up for wear and end thrust is provided for. An automatic cut-out switch is placed inside the stand, with which to stop and start the motor.

RAPID-CUT POWER SAW.

The cut herewith shows the improved rapid-cut power saw manufactured by the Robertson Mfg. Co., Buffalo, N. Y. This machine is strong, well made and will cut hard or soft metal up to 4½ inches, round or square. The saw frame is hung in a swinging carriage frame, and the action of the crank



Power Saw Cutting Thin Disks from end of a Bar.

automatically relieves the drag of the saw on the return stroke, and thus the saw cuts faster and lasts longer.

The sliding balance weight enables adjustment to be made with the greatest ease for the hardness of metals. The movement of the frame is so true in line with the crank that the full stroke of saw allows the cut to be made with no friction on the saw other than that due to the set of teeth. One hundred and fifty-four cuts have been made of a 2-inch round steel bar with one saw, slicing them off 1-32 inch thick; and, for a test, cuts less than 1-64 inch thick have been taken, perfectly parallel.

When the saw has completed a cut the machine automatically stops. The frame when raised for the next cut is

locked by a gravity locking lever, a most convenient device to apply to this type of machine.

The drive pulley is provided with a clutch, a countershaft not being required. The machine is furnished with a stop gage for cutting a number of pieces the same length. The floor space it occupies is 15x34 inches; the height of the machine is 34 inches; the size of pulley, 2½ by 14 inches; the length of stroke, 6 inches.

NEW MODEL MILLING MACHINES.

The Becker-Brainard Milling Machine Co., Hyde Park, Mass., have placed upon the market a new line of plain and universal milling machines from new designs and patterns. These machines, one of which is here illustrated, embody many new features, special attention being given to strength, power and rigidity in order to meet the demands of modern milling machine practice.

In the universal machines the spindle is connected with the change feed mechanism by a train of three spur gears, which eliminates the usual feed pulleys and belt, giving the positive gear drive necessary for heavy and rapid cuts.

The change feed mechanism obviates loss of time in changing gears. The feed is obtained and driven by the main spindle through a train of three spur gears on the back of the machine which drive two nests of change feed gears in the column. By compounding the gears in the upper nest, the various changes of feed are secured, giving, with the quick change in the gear case on the outside of the machine, twenty changes of feed for each spindle speed. Levers, operating the change feed mechanism, are conveniently located on the side of the feed box. All changes may be made by the operator without stopping the machine or changing his position,

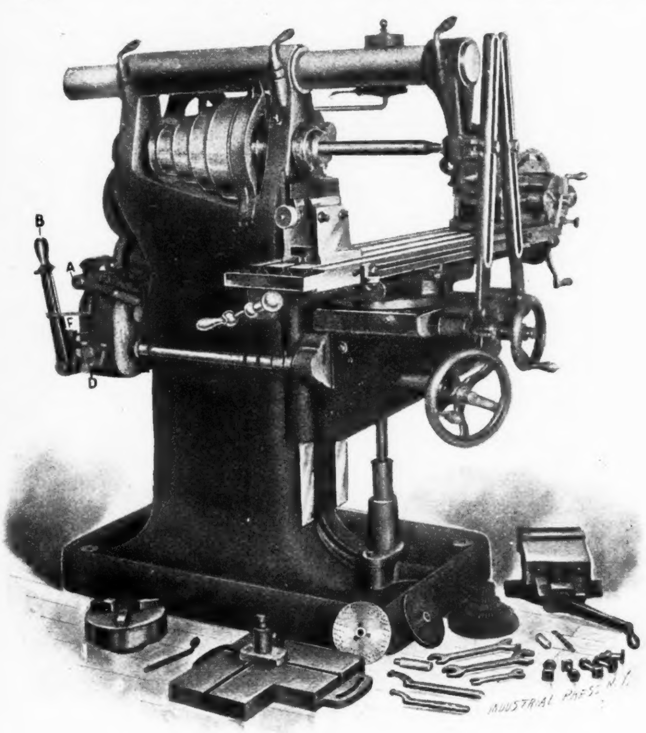


Fig. 1. Becker-Brainard Milling Machine of New Design.

by the simple movement of the levers, which brings them into the position indicated on the index plate. This index plate has each feed plainly marked on its surface, showing the exact position to which the levers must be brought to give a desired feed per revolution of the spindle. For example, if a feed at the rate of .017 per revolution of the cutter is to be obtained, lever *B*, shown by the cut, is placed in the notch 3 on the lower quadrant *C* and then the lever *A* is brought to the line marked 3 opposite the space .017 on the index plate. The quick-change lever *D* on the lower side of the feed box is then moved to the hole marked "slow" and the desired speed is obtained. Should it be desired to increase the feed, lever *A* is moved so as to point to the line at 3 prime (marked with a dash below) on the index plate and .019 is obtained. If the feed is to be decreased lever *B* is moved to notch 4 on quadrant *C* and .013 is obtained. When the fast feeds are desired, the quick-change lever *D* is thrown into the hole marked "fast" and the same operation performed as described above.

Power is transmitted from the change feed mechanism through the telescopic shaft connecting by gears the longitudinal, transverse and vertical feeds, which are reversed by a lever on the side of the knee. Both transverse and vertical feeds are operated and controlled by a lever, located on the side of the knee, which, when central, disconnects both feeds and when thrown into position for one feed it is impossible to connect the other.

An important feature is a clutch arrangement enclosed in the hubs of the handwheels which operate the vertical movement of the knee and cross movement of the carriage. When

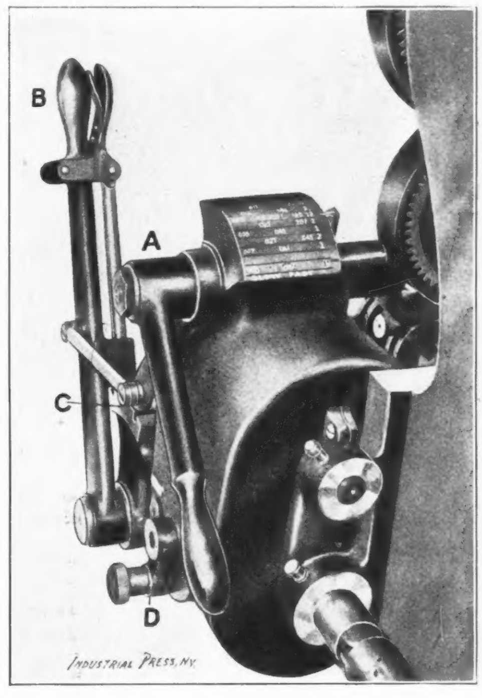


Fig. 2. Feed Box of Becker-Brainard Milling Machine.

either the knee or carriage has been set to the required position, the clutch may be instantly disengaged by pressing in the knob on the front of the handwheel, thereby preventing any accidental change from their fixed position and also preventing the handwheels from revolving when the automatic feeds are thrown in.

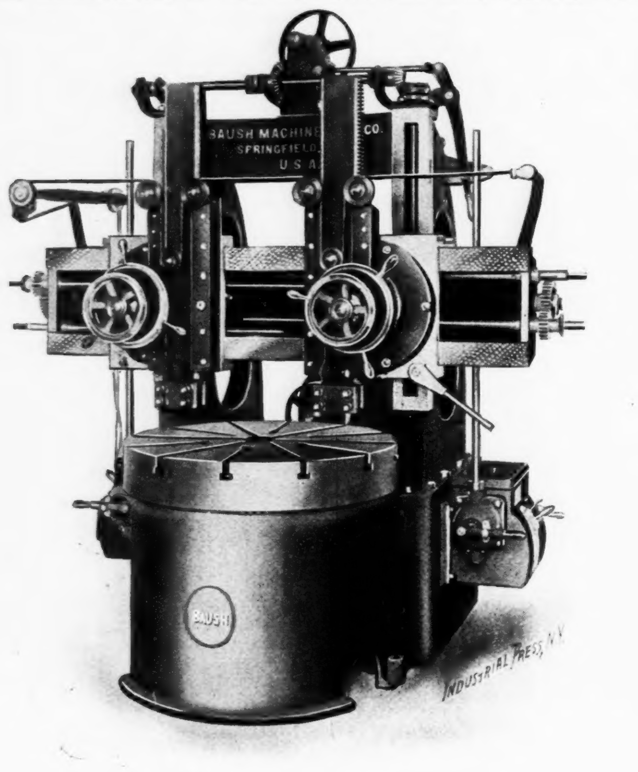
The knee, which is of the box type, provided with a telescopic elevating screw, makes holes in the floor unnecessary and allows the machine to be placed regardless of beams or foundations. The thrust of the screw is taken by ball-bearings.

The base of the machine is very solid, thereby absorbing vibration. The arm is a straight steel bar, so that any of the regular attachments can be placed in position without the necessity of removing the arm.

BORING AND TURNING MILLS.

A line of boring and turning mills in sizes 37, 41, 51, 54 and 61-inch is now manufactured by the Baush Machine Tool Co., Springfield, Mass. All sizes of the machines are equipped with a number of devices, making them well adapted for the rapid production of all classes of work within their capacities. The illustration accompanying this description is of the smallest or 37-inch size. All the mills have independent feeds operated by a device on the Hendey-Norton principle. In the 37-inch machine there are 15 changes, ranging from 1-64-inch to 9-16 vertical and from 1-64 to ⅞-inch horizontal, per revolution of table. A change from one to the other can be made almost instantly without stopping the mill. The heads can be operated independently of each other and by means of a split nut and rack and pinion can be moved back and forth very quickly. The cross rail is raised and lowered by power, the pulley being placed in the center. It is

started and stopped by a lever, and the pulley is belted from below. The table can be removed and replaced by an independent or a universal chuck. It has an outer bearing with a self-oiling device which keeps it constantly lubricated. The main bearing is large and long with a hole through the center to allow the chips to pass through to the bottom of the mill without clogging, from whence they can be removed. Arrangements have been made so that the mills be driven by a motor by removing the cone and bearing and attaching the motor to the bed. The back gears are so located that they can be thrown in and out by means of a lever, without the use of a lock nut.



Thirty-seven inch Boring Mill—one of a New Series.

IMPROVEMENTS IN THE GOULD & EBERHARDT SHAPER.

Gould & Eberhardt, Newark, N. J., are applying an improved sleeve cone support to their shapers and other machine tools, which is designed to overcome the evils arising from an overhanging cone without outer bearing support. The cone *C*, Fig. 1, is supported on a sleeve bearing *B* and drives the shaft *A* through the clutch flange *D*. Connection is made between the cone *C* and the flange by means of taper pins, the pins being a tight fit in the flange and an easy fit in the cone. By employing this mode of construction the stress of the driving belt is carried entirely by the rigid sleeve journal, which is bolted by means of a flange to the side wall *E* of the shaper or other machine to which it may be applied. The driving shaft having only to transmit the torsional stress incident to driving the machine, the wear on it is reduced to a minimum, which insures the proper meshing of the driving gears indefinitely. With ordinary attention in the matter of lubrication this bearing should outlast the machine. All parts of the sleeve bearing are cast iron.

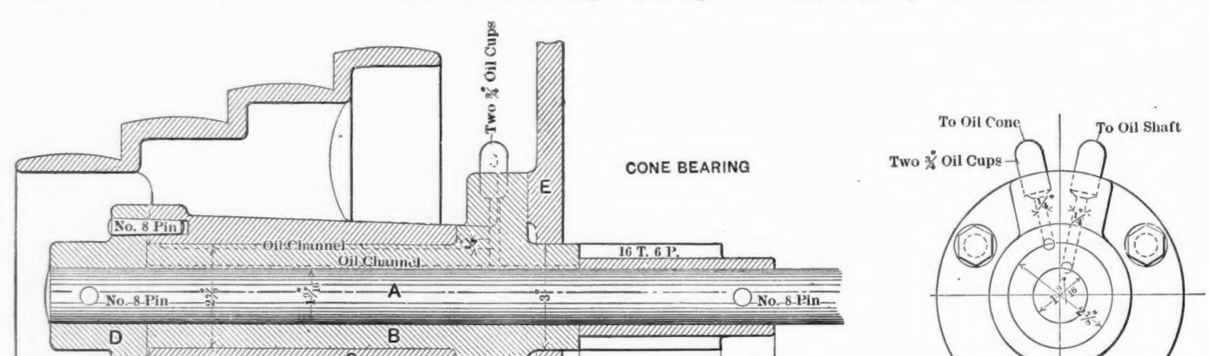


Fig. 1. Sleeve Support for Cones and Pulleys.

Fig. 2 shows a shaper to which the improved cone support has been applied. This machine also embodies a number of other improvements of interest. The connecting-rod to the cross feed has a friction slip joint by means of which it automatically adjusts itself to the correct length when the table is raised and lowered. The friction joint also prevents breakage of the feed gears should the feed become blocked by accident or by the carelessness of the operator.

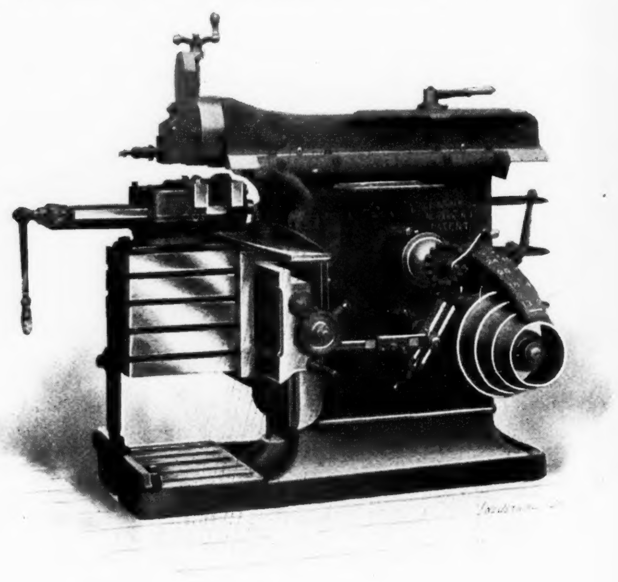
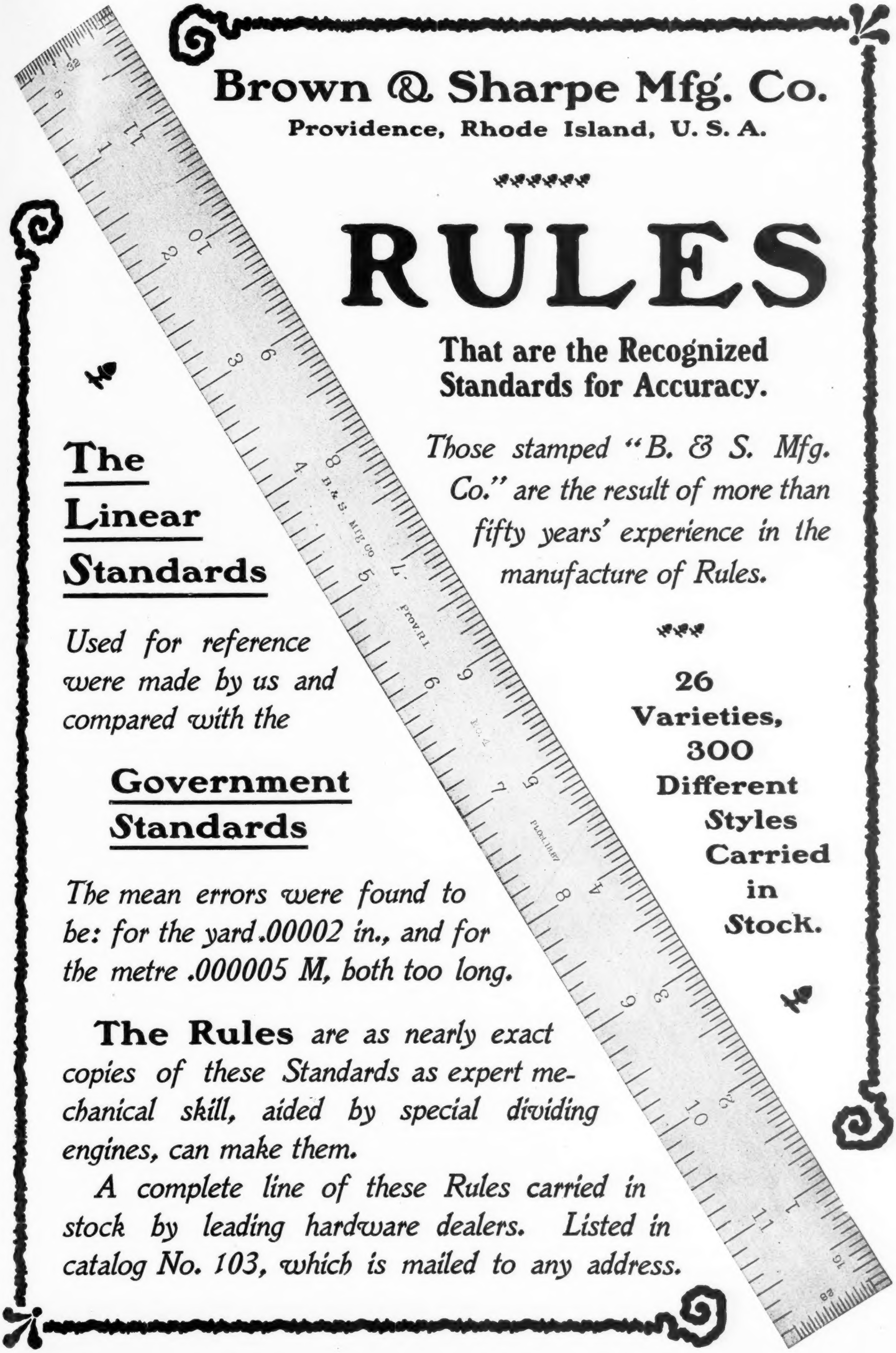


Fig. 2. Improved Gould & Eberhardt Shaper.

An arm projects over the cone, which bears numbers cast on the top corresponding to the different steps. These indicate the proper speeds for different lengths of stroke. All oil holes are provided with filter covers, which prevent the ingress of dirt, chips, etc., and filter all lubricant fed to the bearings. All the bearings are bushed where the wear is likely to become appreciable, so that all shafts may be readily brought back to their original centers. The other features, such as striking place on vise, stiffened ram, vertical graduations on vise, etc., which distinguish this tool, have been described before.

Brown & Sharpe Mfg. Co.

Providence, Rhode Island, U. S. A.



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Those stamped "B. & S. Mfg. Co." are the result of more than fifty years' experience in the manufacture of Rules.

26 Varieties, 300 Different Styles Carried in Stock.

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Used for reference were made by us and compared with the

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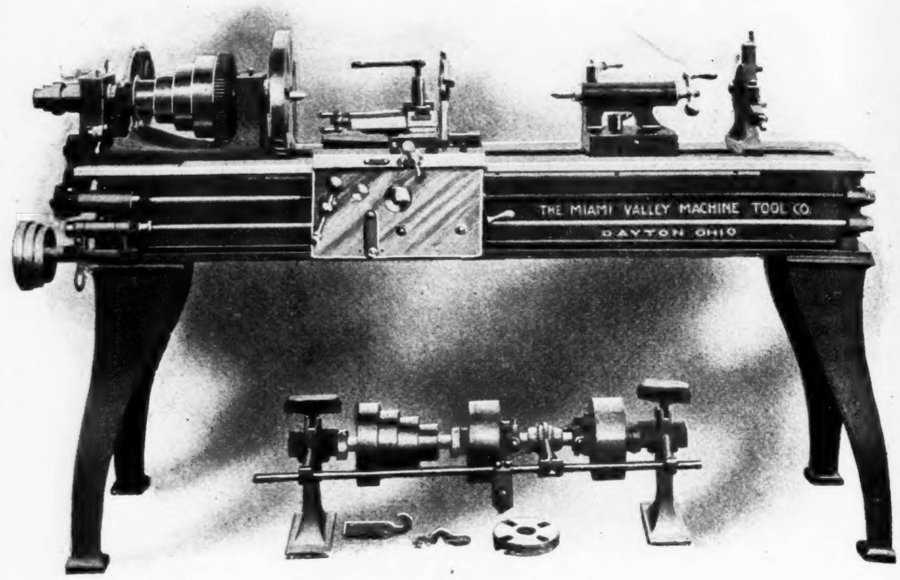
The mean errors were found to be: for the yard .00002 in., and for the metre .000005 M, both too long.

The Rules *are as nearly exact copies of these Standards as expert mechanical skill, aided by special dividing engines, can make them.*

A complete line of these Rules carried in stock by leading hardware dealers. Listed in catalog No. 103, which is mailed to any address.

NEW 13 1-2 INCH LATHE.

A new $13\frac{1}{2}$-inch lathe is shown in the illustration, manufactured by the Miami Valley Machine Tool Co., Dayton, O., for whom the Patterson Tool & Supply Co., Dayton, are the selling agents. No novel features have been introduced in the design, the main considerations having been to produce a lathe with parts of ample proportions, convenient to operate, and durable and accurate in construction. The spindle is of high-grade steel, with ground journals and phosphor-bronze boxes. The cross feed is graduated. The chasing stop is always with the lathe, and it is impossible to throw in rod and screw feeds at the same time. The feed cone is provided with a swinging tightener. The centers are large, with no bushing in the spindle, but a safety plug is provided to avoid accident when the center is removed. The tailstock is of the overhanging style, with set-over. The feeds in head and apron are reversible. The head and tailstocks are fitted to the bed with a V at the rear and flat bearing in front, permitting the cross-bridge of carriage to be heavy and rigid. Besides the belt and rod-feed, a positive-feed can be obtained by engaging gear on leadscrew to the feed-rod. The carriage is provided with lock-screw. It has V-bearing in front and flat bearing in rear, and is gibbed. All sliding bearings on the V's are fitted to completely cover them, and avoid wearing a ridge in them. The power cross-feed is thrown in and out by moving a button. The countershaft has double-friction pulleys, simple in construction and easy of adjustment. Care has been taken to insure perfect facilities for oiling all bearings, especially in the apron. The compound rest is graduated in degrees.



Thirteen and One-half Inch Engine Lathe.

The front bearing of the spindle is 2 inches diameter, $3\frac{3}{4}$ inches long; the rear bearing of spindle, $1\frac{5}{8}$ inches diameter and 3 inches long, and the hole through the spindle 1 1-16 inch. The diameters of the head-cone pulley are $3\frac{1}{2}$, 5, $6\frac{1}{2}$ and 8 inches. The ratio of the back gearing, 9.1 to 1. The lathe cuts threads 4 to 64, including $11\frac{1}{2}$.

IMPROVED TAILSTOCK FOR LATHES.

The accompanying illustration is of a tailstock which J. G. Blount & Co., Everett, Mass., are applying to a new line of speed lathes. The tailstock has a combination wheel and lever feed and when required the lever can be readily applied by dropping it over two pins, one of which serves as a fulcrum and the other for moving the tailstock slide. Then by

Tailstock with Special Adjusting Device.

releasing two thumbscrews at the sides the slide is released so that it can be moved by the lever. Another important feature is the arrangement for adjusting it up or down by means of the two wedges seen in the illustration projecting between the body and base of the tailstock. These wedges can be pushed either way by tapping with a hammer, bringing the dead center accurately in line with the live center of the lathe, after which the two parts are locked securely together by means of cap screws. The tongue cast in the center of the base, which appears in the illustration, fits a dovetail groove in the base of the tailstock and keeps it accurately in line sidewise.

THE "CHICAGO" COUNTERSHAFT.

A very simple and compact countershaft of novel design, called the "Chicago Pullet," has recently been brought out by Hill, Clarke & Co., Chicago. It is thrown in or out by merely a pull on the cord attached to a weighted lever which is set on a pivot with just enough eccentricity to throw in the friction disk driving the main pulley or cone. The weight is proportioned to hold the friction well in place, without undue pressure, and the contact roller is made of sufficient size so that

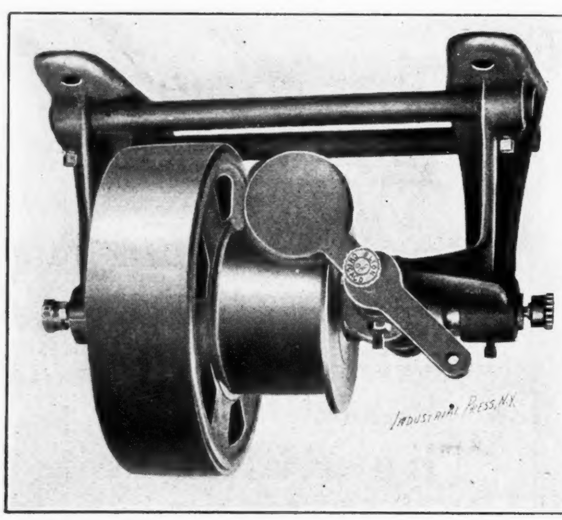
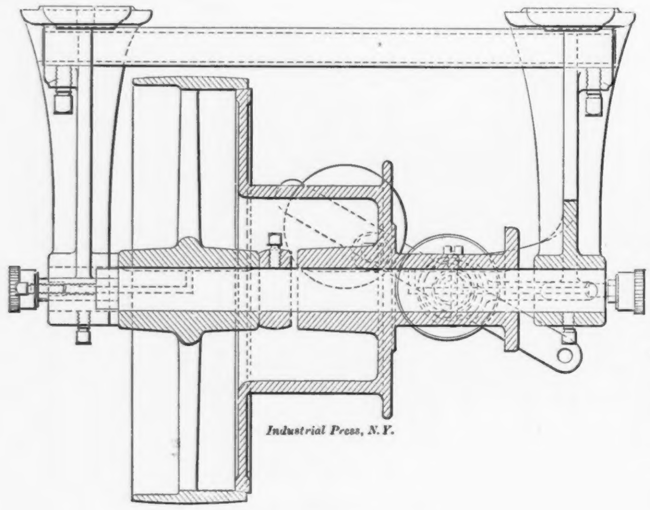


Fig. 1. Countershaft which is both Started and Stopped by Pulling an Attached Cord.

it runs comparatively slow. It does not run when the clutch is out. Allowance is made for taking up any wear, so that the weighted lever will act at the best angle and give the proper throw to the eccentric.

The shaft is stationary in the hanger and the pulleys revolve upon it, thus giving them a long bearing. The shaft is drilled longitudinally from both ends and grooved to distribute the lubrication, which is effected by grease cups. The contact roller also revolves upon its shaft and is lubricated in like manner. In order to accommodate different settings and directions of drive, the frame is constructed to take the "throw-over" lever at either side. The method of mounting upon heavy pipe allows the countershaft some adjustment in setting up.

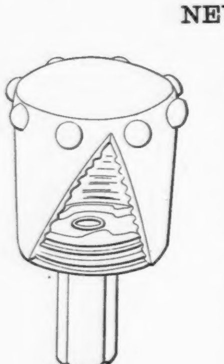
This construction also allows the use either of a single driving pulley or a cone pulley of several steps, as preferred, since the countershaft does not require a shifting belt. Further particulars regarding the countershaft will be furnished by Hill, Clarke & Company, at Chicago, Boston or New York.



Industrial Press, N. Y.

Details of Countershaft.

NEW GREASE CUP.



Industrial Press, N. Y.

Grease Cup for Automobiles.

Now that automobiles have become a staple product in the market there are a great many fittings of various kinds manufactured expressly for use on automobiles. Among these are oil cups of various descriptions, of which one was shown in a recent number of this paper. In the illustration herewith is shown a grease cup for automobile use, made by Chas. H. Besly & Co., Chicago, Ill. It is of a design similar to that of their standard Badger grease cup, but is of double the depth and the stem is made proportionately longer. The cup is of cast iron, and the stem of bar steel drilled and threaded, so there is no danger of its breaking off. The internal thread of the cup is a round thread which will not strip, clog or cross. The round projections at the top of the cup enable one to secure a firm grip for unscrewing, and also make it possible to attach a wrench if found necessary.

* * *

FRESH FROM THE PRESS.

L. L. Cline, founder of the Trade Paper Advertising Agency, Hodges Bldg., Detroit, Mich., is now issuing a quarterly publication entitled "The Trade Press," a copy of which has reached us. This journal is to be devoted especially to the writing of advertising matter for mechanical papers and others.

Arithmetic of Electrical Measurements, by W. R. P. Hopps, and revised by Dr. Richard Wormell. Published in England and for sale by D. Van Nostrand, 23 Murray St., New York. 112 pages, 12-mo. Price 50 cents.

The chapters of the book take up joint resistances, division of current in branch circuits, strength of current with cells in parallel, in series and in opposition, electromotive force, battery power, best arrangement of cells, resistance of conductors, electric lighting, etc. The book has proved useful to students who are learning to make electrical calculations and wish to have a convenient collection of formulas and examples for practice.

Self-Propelled Vehicles, by James E. Homans, A. M. Published by Theo. Audel & Co., 63 5th Ave., New York. 632 8-vo. pages, with nearly 500 engravings. Price $5.00.

This book contains a collection of notes, data and descriptive matter relative to the various types of steam, gasoline and electrical motor carriages. The book is non-technical in character and is intended for the general reader interested in the subject of automobiles. Such a person will here find a great mass of matter, largely descriptive, reviewing the present state of automobile construction. Certain technical points are explained in a way to be understood by the general reader, such, for instance, as differential equalizing gears, different types of steering gear and the operative principles of steam, gasoline and electric types of carriage. The illustrations are largely reproduced from catalogues or articles that have appeared elsewhere, although many have been made expressly for this work, and while not so attractive as newly made cuts, are sufficiently clear and numerous to serve the purpose of supplementing the text. The author has evidently touched upon the most important subject pertaining to automobiles, and gives chapters upon the boilers, including flash boilers, boiler feeding, burners, carburetters, vaporizers, etc. The parts of the carriage itself are also taken up and there are chapters upon motor carriage wheels, springs, ball and roller bearings, brakes, etc. The explosive engine receives rather more attention than any other subject. Taken altogether it is probably the most complete American treatise on automobiles and will give one a very full and correct impression of current automobile practice.

Water-tube Boilers, by Leslie S. Robertson. Printed in England and for sale in America by the D. Van Nostrand Co., 23 Murray St. and 27 Warren St., New York. 213 8-vo. pages, illustrated. Price $3.00.

This book is devoted entirely to water-tube boilers of both American and foreign types, and the text is mainly descriptive, there being little mathematical work. It is really a collection of illustrations pertaining to the most prominent types of water-tube boilers. It traces the history of water-tube boilers, showing some of the earlier forms, and discusses modern types for stationary purposes, and contains descriptions of a number of launch boilers and marine boilers for larger vessels. The book is made up from a series of lectures upon water-tube boilers delivered by the author at University College, London.

The Prevention of Smoke combined with Economical Combustion of Fuel, by W. C. Popplewell. 203 pages and 46 illustrations. Published by Scott, Greenwood & Co., London, and D. Van Nostrand Co., New York. Price $3.50 net.

The prevention of smoke in cities and towns is always an important subject, but at the present time it is of unusual interest in great cities like New York on account of the great anthracite coal strike. New York, because of its closeness to the anthracite regions of Pennsylvania, has always used anthracite coal in preference to bituminous coal, as it is usually as cheap for the steam sizes. Consequently New York has enjoyed the reputation of being the cleanest city in the world, not so much, perhaps, because of the strenuous efforts of its officials to make it so, but because of the cheapness of hard coal. Now that the coal strike has made it impossible to get anthracite coal New York is using soft coal, with the consequence that many of its chimneys are pouring forth volumes of black smoke in a manner that rivals those of Pittsburg and of Western cities. The plants that are fortunate enough to be equipped with automatic stokers are enabled to burn the unusual fuel without serious difficulties in preventing smoke. When it is considered that property is more valuable, the death rate is lower, the moral conditions are better, the damage to fine fabrics less and conditions to a high standard of living far more favorable where smoke and carbon deposits are not known, the prevention of smoke at once becomes a subject of the greatest importance.

The book in review treats of the smoke problem as found in England. It is shown that the difficulty there is much more serious than here, as soft coal is used for almost all domestic fires. In London the volume of smoke poured out daily by these fires is probably equal to if not greater than that emitted by the chimneys of manufacturing establishments. The problem is therefore a much more serious one to combat than here where manufacturing establishments are the chief offenders. Yet the conditions are not considered hopeless and means and ways are pointed out that if adopted generally would materially abate the evil. Various forms of grates and furnaces for house use are described briefly. Chapter I. treats of fuels and combustion, chemical action, quantity of air required for perfect combustion, formation of smoke, effect of air supply on the formation of smoke. The following chapter discusses hand firing and describes forms of furnaces designed for smokeless hand firing. Then follow descriptions of various mechanical stokers, powdered fuel firing, gaseous fuel and the means of producing it, smoke observations, standard smoke tests, etc.

ADVERTISING LITERATURE.

MONTGOMERY & Co., 105 Fulton St., New York. Catalogue No. 21, entitled the "Tool Catalogue." This treats very completely of the large line of small tools, factory supplies and light machinery carried by this company. The catalogue contains 704 pages and is very profusely illustrated. A complete index is given, and the catalogue will be most valuable to anyone interested in this line of goods. The pamphlet entitled "Confidential Prices," accompanying catalogue No. 21, gives the discount on all the articles manufactured.

THE RAND DRILL Co., 128 Broadway, New York, have issued a timely pamphlet showing the progress of the work on the New York rapid transit subway. The book is designed primarily to advertise the fact that the Rand air compressors and compressed air drills are used extensively by the different contractors in excavating for the tunnel. In addition to a general description of the tunnel and of the work so far accomplished, there is a brief review of the various attempts at rapid transit in New York City, including the surface and elevated roads, as well as the attempts to start the great underground system. The illustrations are mainly from photographs.

THE FOSDICK MACHINE TOOL Co., Cincinnati, O. June, 1902, catalogue, standard size, of the radial drills and drilling machinery manufactured by this company. This is a handsome catalogue, containing many fine half-tone illustrations of the various sizes and styles of the company's drills, together with complete descriptions of same. There is also a half-tone showing the company's works and one giving a view of a part of the shop where the radials are built. Space is also given to a large number of copies of letters from different firms expressing their approval of these radials. Catalogue will be forwarded when applied for.

MANUFACTURERS' NOTES.

PAWLING & HARNISCHFEGER, Milwaukee, Wis., send us a statement of orders received from 15 well-known firms in this country for cranes and hoists of their manufacture.

THE BURT MFG. Co., Akron, O., have received an order from the Detroit Copper Mining Co., Morenci, Ariz., one of the largest copper mines in the world, for two 50-gallon Cross Oil Filters, making ten of these filters in use in their mines.

THE CLEVELAND PNEUMATIC TOOL Co., Cleveland, O., have recently opened up an office at 411 Park Bldg., Pittsburg, Pa., represented by Chas. L. Nelson, and at 34 Lemoine St., Montreal, Canada, represented by N. J. Holden.

THE COLBURN MACHINE TOOL Co., Franklin, Pa., manufacturers of high-grade machine tools, state that work on their new plant is progressing very nicely and they are getting in their equipment and shall have their machinery installed and works in full operation in from about thirty to sixty days.

THE U. BAIRD MACHINERY Co., Pittsburg, Pa., has been incorporated under the laws of the State of Pennsylvania, the new name of the company being the Baird Machinery Co. The officers are Messrs. C. A. Wolfe, H. A. Reed, W. B. Wolfe, O. P. Meckel and J. L. McCartney.

THE NEWTON MACHINE TOOL WORKS, 24th and Vine Streets, Philadelphia, will shortly issue a new catalogue 6 x 9 consisting of about 250 pages. The company would be pleased to have the addresses of all those desiring a copy and all requests will be carefully attended to.

THE BUFFALO FORGE Co., Buffalo, N. Y., state that their products are in steady demand not only in the United States, but also in European countries. They send us a list of 16 orders received through their different branch houses for steel plate steam fans, direct-connected Buffalo engines, etc.

THE CLEVELAND PNEUMATIC TOOL Co., Cleveland, O., inform us that the contracts for their new plant have been awarded to Messrs. J. A. Reaugh & Son, of Cleveland, O. It is expected to have the plant completed and ready for operation within 90 days. The plant will be equipped with the most modern machinery and appliances for turning out the largest amount of work in the shortest time.

THE AUTOMOBILE & CYCLE PARTS Co., Cleveland, O., since August 1st have transacted and will continue hereafter to transact their business under the name of the Federal Mfg. Co. This change of title will not affect the management of the company or the business of their factories. The company inform us that their products are so diverse that a comprehensive name became a necessity.

GEORGE WILLIAM HOFFMAN, 295 E. Washington St., Indianapolis, Ind., sole manufacturer of the "U. S." metal polish and "Bar Keeper's Friend" and other specialties, sends us a circular treating of these specialties. This polish may be had in powdered or liquid form, as desired, and is used to remove stains, grease, smut and tarnishings from plated or polished metal, marble, porcelain, glass, wood, etc.

THE BUFFALO FORGE Co., Buffalo, N. Y., have been awarded the contract for the installation in the mines of the Continental Coal Co., Glouster, O., of three 250-inch fans for the purpose of ventilating and exhausting fumes, smoke and dangerous gases. This plant is similar in many respects to that of the Modoc Coal Mining Co., located at the same place and recently installed by the Buffalo Company.

THE FALKENAU-SINCLAIR MACHINE Co. is a new company organized for the manufacture of machine tools and located at 109-115 North 22nd St., Philadelphia. This company has taken over the entire plants and business interests of A. Falkenau and of the Philadelphia Machine Tool Co. Besides the building of machine tools and special machines, and contracting for machines in large quantities, the company's full lines of presses and machines for working sheet metals, hydraulic machinery and testing machines will be continued and extended.

THE ROYERSFORD FOUNDRY & MACHINE Co., Royersford, Pa., report a very active business in the sale of their punch and shears. Several of their machines have just recently been shipped to Manning, Maxwell & Moore, New York, N. Y., and a carload to the Marshall & Huschart Machinery Co., Chicago, Ill. They have made the Marshall & Huschart Machinery Co., 62-64 So. Canal St., Chicago, Ill., their exclusive agents for the sale of their machines in the States of Illinois, Indiana, Michigan, Wisconsin and Ohio, the city of Cleveland excepted.

THE PHILADELPHIA PNEUMATIC TOOL Co., Philadelphia, Pa., report an unprecedented rush of business, their manufacturing capacity being taxed to the utmost to keep up with orders. The increasing demand for the Keller rotary drills is particularly noticeable. They state that four of the large eastern steel companies have recently purchased Keller tools to the aggregate number of 237. One of the western trunk line railroads has recently made a contract with this company to purchase at least 1,500 Keller tools within the next eight months, and a cable order for Keller tools was received last week from Bilbao, amounting to several thousand dollars.

THE AMERICAN SCHOOL OF CORRESPONDENCE, Boston, Mass., has recently made an arrangement whereby the students are admitted to the classes of one of the prominent technical schools without further examination, and their work counts toward a degree of B. S. Ambitious young men who cannot afford to give four years to study for a college degree can now do part of this work at home and finish at a resident technical school. The Trustees of the American School have been offering a limited number of free scholarships; after September 30th the offer will be withdrawn. There is still an opportunity, therefore, to obtain, free, a course in mechanical, steam, textile and sanitary engineering and mechanical drawing.

PAWLING & HARNISCHFEGER, Milwaukee, Wis., makers of electric cranes and hoists, have just acquired the Gardiner Campbell Co., property adjoining their works. This property is 200 by 150 feet, and the three-story building is being remodeled to supply additional machine shop facilities, and to provide extra pattern storage. The foundry is being changed over, and added to. In the entire building will be placed a modern foundry equipment. Among the improvements will be two P. & H. electric traveling cranes. Their present power plant is also being enlarged and new boilers, engines and another generator will be provided. They state that these improvements will considerably shorten the time required to complete a crane or hoist.

IN the editorial columns of the engineering edition of MACHINERY for this month reference is made to the fact that the Standard Welding Co., Cleveland, O., are now turning out electrically-welded parts for automobile construction. They write us that they are also enlarging their plant by the erection of new buildings to enable them to increase their stock of manufactured tubing in sizes from 2½ inches diameter and smaller. This tubing is uniform in gage, of the best open-hearth steel and is particularly adapted to places where the tubes are to be plated with nickel or other similar finish. The company also wish to announce that they are prepared to contract for various classes of work. They will either electrically weld stampings and forgings furnished them by manufacturers, or will do the whole work complete.

THE NEW PROCESS RAW HIDE Co., Syracuse, N. Y., have recently made arrangements with Messrs. Geo. Angus & Co., Ltd., Newcastle-on-Tyne, England, prominent manufacturers of leather, whereby the English concern is to establish a plant in England for the manufacture of rawhide gears and other products under the patents and secret processes of the New Process Raw Hide Co., using the latter company's trade mark. This plant it is expected will take care of the company's business not only in Great Britain, but throughout Europe, Messrs. Angus & Co., having offices in nearly all of the principal cities. The English company will shortly place orders with American firms for the latest gear-making machinery and will proceed at once with the fitting out of the new factory which will be located at Newcastle-on-Tyne.

THE DERRY COLLARD Co., with offices at 256 Broadway, New York City, has been organized for the purpose of publishing and selling educational books, charts, models, etc., for readers of technical literature. One of the first books to be brought out will be a treatise on hardening, tempering and annealing steel, by our contributor, Edw. R. Markham, the consulting expert. A locomotive valve model will also soon be ready. A new policy has been adopted by this company for the sale of technical books, in that they will send books to any person for examination before he pays for them. If he finds them satisfactory he can then remit, and if not, the books can be returned. Detailed information will also be furnished about the technical merits of any book, whoever the publisher, either by circular or by written letter. The office of the Derry Collard Co. is fitted as a reading room and any mechanics visiting New York will be welcome there. The president of the company is Mr. Fred. H. Colvin, who was formerly editor of MACHINERY.